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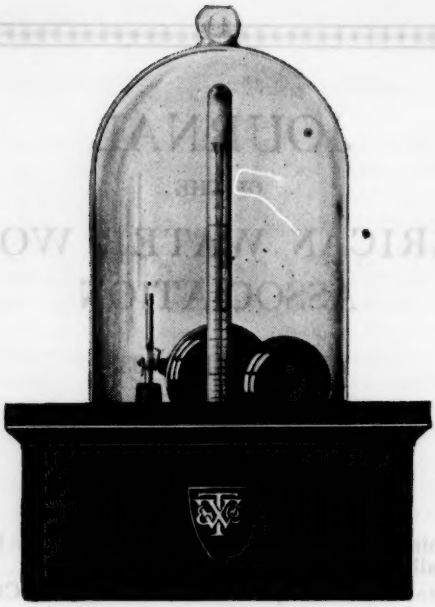

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Vol. 25 FEBRUARY, 1933 No. 2

THE WASHINGTON SUBURBAN SANITARY DISTRICT

By Harry R. Hall

(Deputy Chief Engineer, Washington Suburban Sanitary District, Hyattsville, Md.)

Slightly over twenty years ago a group of citizens residing in Montgomery and Prince Georges Counties, Maryland, just beyond the boundary of the District of Columbia, met with members of the State Board of Health in Washington to discuss the increasingly bad sanitary, and unsatisfactory water supply, conditions which they had been viewing with alarm as they saw their section of the State growing rapidly in population along with the development of the nation's capital. Thus was the movement commenced which, after nearly seven years of indefatigable effort, culminated in the formation in 1918 of the Washington Suburban Sanitary District.

The District of Columbia is bounded on three sides, in a distance of 25 miles, by the State of Maryland and on the fourth by the Potomac River, which separates it from Virginia. Thus with no physical line of demarcation the natural tendency for development of the territory outside the District boundary was in Maryland, and as a result four well defined areas of settlement, consisting of many small closely built-up communities, had grown up along the steam and electric railways which radiated from Washington. A few of the communities became incorporated into small municipalities, but the majority were merely under the county governments which also ad-

ministered the affairs of a large rural section and were able to do little or nothing toward providing major improvements in the suburban areas. Organization for public works was the exception rather than the rule and the prospect for orderly development was not encouraging. Each town or unincorporated settlement was trying to improve its own condition, it is true, but there was no concerted action towards advancing the interests of Washington's suburbs as a whole.

Water supply and sewerage presented the most vital and difficult problems in this suburban area having approximately 20,000 people. Where public service was rendered at all it was through small municipal or community systems, which served only about one-fourth of the population. The remainder depended upon private wells, cesspools and outhouses. Most of the water and sewerage systems which did exist were inadequate. Proper fire protection was not available and in some cases there was none at all. Some systems furnished water unsafe for human consumption, others that of questionable purity or unsatisfactory physical quality. The sewerage systems, like the water supplies, had been built to accommodate only the immediate communities within which they were located. Usually they were not installed in accordance with sound engineering practice and many of the lines were so shallow that they could not drain abutting property in an adequate manner.

Methods of sewage disposal were giving rise to offensive and dangerous conditions. The sewers discharged into the nearest water course regardless of the proximity of other communities just below. In the rare instances where treatment works existed, little attention was given to operation and they were of little value in preventing nuisance or safeguarding health.

Communities without public or quasi-public systems faced a dangerous situation in the use of wells polluted by cesspools or outhouses on the same or adjacent lots.

Naturally these conditions were of great concern to thoughtful citizens. Furthermore, a large number of the residents worked in Washington, either in government departments or in business establishments, and the daily movement back and forth of such a large part of the population provided a direct avenue for the transmission of disease to the inhabitants of Washington. Also two of the three main streams draining the Maryland area passed into the District of Columbia and their increasing pollution was being viewed with alarm by the officials of the District government.

These were the conditions facing those Maryland citizens when they met in 1911. Their first concern at that time was the question of sewerage and relief of the streams from pollution. The future held no promise of relief through action by individual communities. Unincorporated sections could not hope for service under the county form of government. The towns faced heavy expenditures for developing more distant sources of water supply, for sewage treatment works, and for extension of service mains. Development of the territory was being distinctly hindered. It was realized that thoroughly adequate water and sewerage facilities could be secured only by the establishment of comprehensive systems under a single administrative body.

A resolution was finally passed by the State Legislature of 1912 forming a Commission, without any appropriation, known as the Montgomery and Prince Georges Sewerage Commission, which was charged with the duty of investigating sewerage conditions and reporting upon means for their relief. The services of the newly organized sanitary engineering bureau of the State Department of Health, under the direction of Robert B. Morse, chief engineer, were made available to this Commission. Extensive preliminary surveys were made by the bureau and a comprehensive report, accompanied by a draft of a law creating a sewerage district, was presented to the General Assembly of 1914.

The bill failed of passage, but some of the members of the original Commission persisted in their efforts and another bill, revised to include water supply as well as sewerage, was presented to the 1916 Legislature. An act was finally passed creating the Washington Suburban Sanitary Commission, with a small appropriation, which was directed only to investigate and report upon both water supply and sewerage conditions in a designated area and to report back to the General Assembly of 1918.

This Commission, with further engineering assistance from the State Department of Health, submitted a complete report and a draft of legislation which, after many meetings and legislative hearings, resulted in the formation of the Washington Suburban Sanitary District, slightly more than six years after the first step was taken.

POWERS AND DUTIES OF THE COMMISSION

The Washington Suburban Sanitary District is an overlying municipality, situated partly in Montgomery and partly in Prince Georges

Counties, and covers practically all the Maryland suburbs of Washington. It has at present an area of 102.5 square miles, a population of 65,000 and contains 20 small municipalities, a number of special taxing areas, many unincorporated communities, and much undeveloped territory lying between and around the developed sections. Town boundaries within the area are meaningless as far as its administration is concerned.

A commission of three members conducts the affairs of the District. The County Commissioners of each County appoint one member, upon recommendation of the State Board of Health, and the Governor appoints a third, all for four year terms.

The Commission has all the usual powers accorded to municipalities with respect to the construction and operation of water and sewerage systems. It issues its own bonds, as required, without referendum, but with the approval of the Public Service Commission, and charges and rates are subject to review by that body, upon appeal. It prescribes the amount of annual tax and the front-foot assessments to be collected by the two boards of County Commissioners, said tax and assessments covering fixed charges on the bonds. The Commission fixes and collects service rates to meet maintenance and operating costs. It has the power of condemnation. Plumbing has been placed under the Commission's supervision and all such work must be installed in accordance with its regulations.

Funds for carrying on the construction work are provided by bonds, of which the total amount of outstanding issues cannot exceed 14 percent of the value of assessable property in the District. There is no distinction between bonds for water and sewerage work, the funds being allocated to whatever projects of either kind are contemplated at the time of any particular issue. The bonds are guaranteed as to principal and interest by the County Commissioners of the two Counties, which feature is believed to strengthen their saleability and thus secure a more attractive price. All property within the Sanitary District is subject to taxation for payment of the bonds and the District as a whole is primarily liable for their payment, so the liability of the Counties is only of a secondary character.

Collection and disposal of garbage and refuse and the construction and operation of a system of storm drainage, whenever warranted, constitute other duties of the Commission. The beginning of these services is left to its discretion.

WORK COMPLETED AND PROJECTED

The Commission has acquired by purchase all of the original water and sewerage systems, consisting of about 53 miles of water mains and 55 miles of sewers, and either incorporated them into its unified system or replaced them altogether. It has constructed as many as 50 miles per year of water mains and sewers in the years of greatest activity and at this time controls 285 miles of water and 210 miles of sewer mains. Approximately 13,000 buildings are connected to the water system and 10,000 to the sewer system.

Bonds issued or assumed by the Commission now amount to $9,050,000. The District has grown from a population of 30,000 in 1918 to 65,000 at the present time, and the assessable basis has increased from $24,000,000 to $95,000,000.

Originally the area covered 94 square miles, but in 1924 Gaithersburg and Washington Grove, two incorporated communities seven miles distant from the Sanitary District boundary, requested admission; and in 1931 a large area adjoining the southeasterly end of the District, which had been seriously affected by the drought, insisted on admission. The Commission took no active part in securing the addition of these areas beyond describing to them its financial plan and assisting in the preparation of the necessary legislation. Gaithersburg and Washington Grove are served by the same systems of water supply and sewerage, which are entirely separate from the main system of the District. The water supply is four drilled wells and the sewerage system has four small sewage pumping stations and a sewage treatment works of the sprinkling filter type with primary and secondary settling tanks and separate sludge digestion.

So great has been the demand for extension of the water and sewer service to take care of the rapid growth of the Sanitary District that permanent water supply works and sewage treatment plants, except for Gaithersburg and Washington Grove, have not yet been constructed.

Two water filtration plants and pumping stations have been erected at Hyattsville and at Burnt Mills, with daily capacities of 1,000,000 and 3,500,000 gallons, respectively. These constitute the entire water supply of the Sanitary District. Both take water from Northwest Branch, which has a drainage area of 27 square miles at Burnt Mills and 35 square miles above the Hyattsville intake. At Burnt Mills a small intake reservoir of 30,000,000 gallons capacity has been

constructed on the stream to eliminate low-lift pumping and overcome troubles that had been experienced with ice and leaves at the intake and to bring about reduction in turbidity of the raw water which has been as high as 10,000 parts per million.

The purification plants produce a water of excellent quality and at ample pressure throughout the Sanitary District. Difficulties have been experienced with tastes and odors. Ammonia treatment to the filtered water has helped reduce complaints, but the tastes persisted particularly after heavy rains. Recently the application of activated carbon to the raw water has resulted in the elimination of tastes and odors.

The present average daily water consumption is 4,000,000 gallons. In hot, dry weather it reaches 6,000,000 gallons and during periods of peak demand water has been used at a rate of nearly 8,000,000 gallons per 24 hours.

Acts of Congress permit the Sanitary District to secure water from the District of Columbia water system and to discharge sewage into the Washington system upon terms prescribed in the laws. Four connections with that water system now exist. These were built during the drought of 1930 when the flow in Northwest Branch decreased to less than 500,000 gallons per 24 hours. Two booster pumping stations with combined capacities of approximately 5,000,000 gallons per day were constructed by the Sanitary District during this emergency so that a sufficient quantity of water could be sent into the Maryland mains. The almost overnight installation of these stations at a time when the Sanitary District was facing a serious water famine makes an interesting story in itself. They were installed for what was believed to be a period of short duration in 1930, but were again called into use in the summer of 1931.

The water distribution system has been given an exceedingly high rating by the Underwriters' Association of the Middle Department and stands among the first five of the 800 systems under the Underwriters' jurisdiction.

The permanent water supply sources will be the Patuxent River and Seneca Creek, which are to the northeast and northwest, and outside the Sanitary District. The former will be used in conjunction with a permanent filtration plant at Burnt Mills, the water for which in dry seasons will be pumped over into the Northwest Branch drainage area from the Patuxent River, and when the area expands to the northeast a plant farther downstream near Laurel will serve

the Prince Georges County section. Seneca Creek will be used for supplying the northwesterly section of the District.

Disposal of part of the Sanitary District sewage will be through the District of Columbia trunk sewers. In several places the smaller trunk sewers now extend to the boundary and there either connect with the Washington system or are in a position to do so when the necessary lines of the latter are sufficiently extended. One of the most important connections already made is that of the sewer in the Rock Creek valley, the connection of which to the Washington system has removed a large part of the pollution from the stream flowing through Rock Creek Park in Washington.

Sewage originating from the easterly section of the District, about two-thirds of the total, will be treated near Bladensburg and discharged into the Anacostia River.

FINANCING THE PROJECT

The financial plan for providing water and sewerage service constitutes one of the most interesting facts concerning the Sanitary District. When the enabling act was framed it was realized that total costs of construction would be far greater than in the ordinary city of equal population, on account of the great expanse of territory to be covered in reaching the many towns and villages as well as the suburban character of the communities themselves. This forecast was well founded, for there are already twice as many miles of water mains and sewers in the District as in the average city of equal population.

It was necessary therefore to develop a plan, if possible, which would not be burdensome to the individual property owner or tenant. Such a plan to be workable would have to be based upon the principle of allocating, as nearly as practicable, the expense to the public and to each individual in proportion to the benefit received. To classify benefits with scientific precision is not necessary, for the most technically accurate scheme would require some modification to satisfy local conditions and prejudices.

In a suburban area of this type, having so many unoccupied lots and unsubdivided frontages along water and sewer lines, it would be manifestly unfair to impose all bond charges on the tax rate on account of the great increase in value accruing to such properties and the relatively small expense which they would bear. The developed properties would carry the greater part of these costs by this plan,

to the extent that an excessive burden would be placed upon them. Yet if the tax rate were to be exempted the bond cost must fall entirely on front-foot benefit charges, unless part of it were absorbed in rates for service. If all of the capital cost were to be imposed as a front-foot rate on properties abutting a water main or sewer, the developed lots would not bear their fair share of the benefits accruing to them and no recognition would be given to the general benefit resulting to those sections close to, but not yet having, water or sewerage facilities, which though somewhat intangible, does exist nevertheless.

These considerations finally resulted in the determination to meet the fixed charges on bonds through a small addition to the tax rate over the entire District and a front-foot benefit charge on properties abutting the water and sewer lines, and to cover maintenance and operating expenses on both water and sewerage systems by water rates. Deviations, naturally, were made from the theoretical plan, as required by local conditions, but the main principles were followed as closely as possible.

It would be theoretically correct to charge the tax rate with at least a proportion of the cost of reservoirs, pumping plants, purification and treatment works, main feeders and collectors, and also much of the expense of general surveys and studies which are necessary to provide for future growth of the area. This sum is spent for the benefit of all property. Residents in outlying areas could not be expected to realize any appreciable advantage to their properties before facilities were made available to them, so as a matter of expediency it was deemed advisable to fix the amount to be raised from the tax rate at a low figure. This amount was first fixed at 5 cents on the $100.00 and later raised to 7 cents.

The greater part of the cost of constructing the systems is carried by front-foot benefit charges on properties abutting the water and sewer lines. This charge is intended to represent the benefit that properties receive from the systems through being accessible to the pipe lines and is applied alike to developed and undeveloped lots. It includes, therefore, something more than the average cost per linear foot for the lines in the streets. Abutting frontage furnishes a simple and comparatively accurate measure of this benefit.

Practical considerations determined that theory be departed from to some extent in the matter of assessing front-foot benefit charges. Property was divided into four classes, business, subdivision, small

acreage and agricultural, with the idea that the longer frontages in the two latter classes would bear a lower rate. The legislature, however, attached an amendment exempting agricultural property from assessment until it secured a connection to the systems and then its assessable frontage was limited to 300 feet. The Commission has placed the highest base rate on business or industrial properties, the frontage in excess of 200 feet bearing a lower assessment. The base rate on the other three classes is the same, but lower than the first class. On subdivision property a lower charge is levied for frontages exceeding 150 feet, while on small acreage the same secondary rate is applied for the first 150 feet of excess and a still lower rate for all exceeding 300 feet. Agricultural property bears the full base rate where connected, although in no case has the full frontage allowable under the law been assessed. Classifications may be varied from time to time as the use of properties changes.

It is the practice in most places to make the front-foot assessments for improvements payable in one sum or in several annual installments covering a period of years, generally not exceeding ten. Such a plan in case of the Sanitary District would cause an excessive burden to fall on many properties owing to the many long frontages and large amount of undeveloped property which would abut the water and sewer lines. It was determined to spread the benefit charge over the life of long-term bonds. These are fifty-year sinking-fund bonds, the sinking fund and interest requirements of which are met by the tax-rate charge and the front-foot assessment. The annual requirements on this basis, therefore, are small and the burden even on long frontages is not great. This feature has done more than anything else to permit the construction of water and sewer systems in a sparsely settled but large suburban area, during a period partly of abnormal construction costs, with little if any greater individual expense than in more congested centers of population. It is the main reason for the financial practicability of such a large project in an area of comparatively limited wealth.

The front-foot benefit charge, which is in effect a small, equitably proportioned, annual tax, still causes much popular misunderstanding and complaint. The uninformed and unthinking citizen multiplies his annual assessment by fifty and protests that he is paying many times the cost of constructing the pipe in front of his property. At first he fails to realize that he is simply paying off a loan of long duration which is bearing the major expense of constructing water and

sewer systems, not just the lines in front of his property. When this is explained to him and also the fact that he can redeem his assessment at any time, based on its present worth, he figures again and then it commences to dawn on him that if he borrowed the money to do this it would cost him much more, for he finds that the Commission is borrowing money at a much cheaper rate than he could—as a matter of fact the interest and sinking-fund requirements combined are less than what he would have to pay for interest alone on a private loan. The law provides that assessments may be paid up at any time, but the number so paid is negligible.

The original law provided that no assessment when once levied could be increased. The Commission had no precedent to guide it and as a result the charges were too low at the beginning. Assessments for later work were made higher, but a most inequitable situation was created. Lack of uniformity prevailed in the charges. The peculiar situation existed in some areas of one block in a certain street bearing one assessment, while the next block, in which construction work was done a year or two later, was assessed a higher rate without deriving any additional benefit. Even with these higher rates on the later construction, sufficient revenue was not secured to wholly meet the annual requirements. The commission sought to wipe out the deficit, without establishing too high an assessment on new construction or increasing to an undesirable extent the general tax, by having stricken out of the law the clause prohibiting any increase in assessment. It then raised the lower assessments in an effort to distribute the costs more equitably. An appeal from this increase was carried to the Public Service Commission, which ruled that the new benefit charges were not unreasonable, but that the legality of the increase could not be passed upon. The case was then taken to the County Courts, which decided that the Commission was without power to increase the benefit charge on any property when once levied.

At the next session of the legislature an amendment to the law was passed making effective the increased rates. This amendment was attacked in the courts, but finally upheld by the Court of Appeals after a decision unfavorable to the Commission in the lower courts. An appeal to the United States Supreme Court resulted in the refusal of that body to review the case, so the increased assessments became effective. To secure the passage of the amendment, however, it was necessary for the Commission to permit the reinser-

tion in the law of the provision prohibiting any increase in an assessment once levied.

The Commission constructs all water and sewer connections as far as the property line, making the same flat charge of $42.50 each for a ¾-inch water service and a 6-inch sewer connection regardless of length or difficulty of construction. Meters are placed on all water services in settings located generally near the property line or curb. The cost of the setting, but not of the meter, is included in the house connection charge. Rates for larger connections vary with the size of pipe.

It was the original intention of the Commission to have the water rates cover only the maintenance and operating expenses of the water and sewerage systems, but the desire to keep the general tax rate at a low figure has compelled it to secure special legislative acts enabling it to pay for construction of reservoirs, purification works, pumping stations and main supply lines through the water rates. This is not in conformity with the fundamental theory upon which the financial plan was based, but it appeared to be the best solution of a financial problem brought up by unanticipated higher costs during the period when the Commission was working out its previously untried plan.

The water rates include an annual ready-to-serve charge varying from $4.00 for a ⅝-inch meter to $360.00 for an 8-inch fire-line meter, and a consumption rate varying from 22 cents per 1,000 gallons for the first 50,000 gallons used semi-annually to 11 cents per 1,000 gallons for all water consumed in excess of 2,500,000 gallons monthly. Public fire hydrant service and water for municipal service are furnished without charge.

The financial plan finally employed by the Commission perhaps does not fully meet the requirements based on a strict analysis of the apportionment of costs, but it is thought to be sufficiently near mathematical accuracy to preserve the equities for all practical purposes, and perhaps as close to such accuracy as local conditions and prejudices will permit. Under this plan property not accessible to a water main or sewer is subject to very little annual expense. Undeveloped land along a pipe line bears a burden which is somewhat larger and which is sufficient to stimulate building, while the developed lots, although averaging considerably larger payments for complete service, still are put to an expense annually amounting to less than three dollars per month for complete water and sewer service.

It is of interest to indicate here just what it costs average properties

under this plan, and typical examples of the manner in which the charges apply to the three types mentioned above will be given. We shall take (1) a property assessed at $6,000, not accessible to a water main or sewer; (2) an undeveloped lot, with a 50-foot frontage assessed at $750, and on a street in which there is a water main or sewer; and (3) a residence on a 50-foot lot, building and lot assessed at $6,000, the property using 60,000 gallons of water annually through a $\frac{5}{8}$-inch meter:

	(1)	(2)	(3)
General tax, 7¢ per $100	$4.20	$0.53	$4.20
Front-foot charge (14¢ water, 14¢ sewer) 28¢		14.00	14.00
Ready-to-serve charge			4.00
Water consumption charge, 22¢ per 1000 gal.			13.20
Total annual expense	$4.20	$14.53	$35.40

It is evident that the cost to the inaccessible property is slight; that the undeveloped accessible lot is not unreasonably burdened, but is provided with the incentive for development; and that an average residence obtains all the advantages of complete water and sewer service for a moderate cost. The front-foot rates given are the maximum existing for subdivision property. Many of the early rates were considerably less, and some are still substantially so even since the advance was made effective.

DIFFICULTIES ENCOUNTERED

Even established municipal governments often meet with difficulties in the installation of water supply and sewerage systems. It was but natural, therefore, that a brand new scheme of organization and an untried financial plan in an area practically one-half again as large as the District of Columbia, lying in two Counties and comprising numerous small municipalities and a large amount of unincorporated territory, would be met by some hostility. Misinformation caused by misunderstanding of the Commission's scheme of operation and powers was spread widely. It was said that the Commission was more powerful than the king. Yet its authority over the work it is charged to perform is not essentially different from that possessed by any municipality for like purposes. As the plan has become better understood and the stimulus given to development of the area become

evident, opposition has greatly diminished. It is now generally realized that without a single agency of this kind to install these systems under a comprehensive plan, the territory could not have experienced the rapid growth it has shown in the past 14 years.

The very character of the area itself imposes obstacles not usually encountered by a single municipality of equal population. Transportation is a considerable item; distances of twenty miles or more are required to be covered. In the early days scarcity of paved roads, and circumferential highways (the main roads all led into Washington) did little to facilitate operations.

Problems of design were presented due to the distances apart of the built-up areas and the necessity of providing immediate service to many sections without an unreasonably high early cost. Study of probable future street developments was required to prevent possible duplication of lines. In a few cases small temporary water lines were purposely laid in streets which must eventually be the routes of main arteries.

Ungraded streets caused additional cost in the laying of mains as greater depths were required to prevent future expense for lowering when grading and paving operations were carried out. It is not unusual to lay water mains as deep as ten feet for considerable distances and probably the average depth is more than six feet, despite the fact that the aim is to provide a cover over the pipe of slightly more than four feet from finished street surface. The Commission now refuses to lay water pipes and sewers in new real estate developments until streets are substantially graded to final elevations, but in existing developed sections service must be given regardless of the condition of the streets.

The ungraded condition of the streets affects hydrant and meter settings as well as main line construction. A change in street grade requires a change in length of hydrant. This condition resulted in the invention by Robert B. Morse, Chief Engineer of the District, of a sliding frost case to be used in connection with a hydrant of well-known make. Raising or lowering the street grade simply requires the replacement of the existing hydrant barrel by a longer or shorter one, and raising or lowering the upper section of the sliding frost case which has a maximum extension of two feet. Thus it is not necessary to dig up a hydrant when the grade change does not exceed the limit of the frost case slide. No method has yet been devised for changing the grade of meter housings easily.

Streets had been laid out originally in the several sections in a haphazard manner without any idea of continuity. It was soon realized that such an uncontrolled development would seriously affect the Commission's operations if allowed to continue. This resulted in placing under the Commission's control supervision of all subdivision layouts and establishment of street grades in the Sanitary District. No plat could be placed on record until it was approved. In 1927 this work was taken over by a planning commission which submits all plats and grades to the Sanitary Commission before giving its approval. Street control has been productive of much good and has aided materially in designing and constructing the water and sewerage systems.

CONCLUSION

After nearly fourteen years of continuous activity in the construction of water and sewer lines in which nearly $10,000,000 have been spent, the Commission's work is still far from complete, but the greater part of the area is now provided with water service and sewers as well are gradually being extended to outlying sections. Construction of the main water supply and sewage treatment works probably will be undertaken during the next two or three years. The District is still growing even during this period of depression and requests for extension of service are being constantly received.

The plan under which the Washington Suburban Sanitary District was established and is operating has served as an example for the foundation of two similar districts in Maryland and is being recommended by the Maryland State Department of Health to towns considering the installation of water and sewerage systems.

ACKNOWLEDGMENT

The engineering work of the Sanitary District, together with all the original preliminary engineering studies and reports from the time relief plans were first considered in the area, has been under the direction of Robert B. Morse, Chief Engineer, to whom the writer is indebted for the helpful suggestions and guidance given to him in the preparation of this paper.

(Presented before the Four State Section meeting, June 7, 1932.)

DISCUSSION

GEORGE W. FULLER:[1] Mr. Hall's paper is very interesting and instructive. The achievements described reflect great credit on those responsible for them. In particular do they show the foresight of the County Commissioners of Montgomery and Prince George's Counties who, with the aid of the engineers of the State Department of Health and of others, brought about the necessary legislation enabling this undertaking to become in many ways a model for joint activities.

Results. The results accomplished are gratifying in several ways to those interested in advancing in suburban areas steps needed for providing a safe public water supply, effective sewerage and sewage disposal. No longer need there be apprehension about the Maryland suburbs of Washington, D. C. in the transmission to the residents of the national capital of water-borne and fly-borne diseases such as related to the earlier polluted wells, creeks and offensive outhouses. These have been eliminated and, with the growing spirit of the times for decentralization of population in metropolitan areas and for suburban development, their sanitary significance is of more practical value than hitherto. The lessons taught by the practical procedures adopted are well worthy of study elsewhere.

It is significant that this area has during 14 years of intensive activities increased in population from 30,000 to 65,000 persons and that the value of property for assessment and taxation has increased from $24,000,000 to $95,000,000 or about 100 percent increase in assessed valuation per capita.

Combining the hygienic and financial accomplishments it is clear that the undertakings of this District Commission have been well worth while and serve as an important chapter in the growing history of district projects.

Regional coöperation. This is a sound policy for suburban areas. It meets the test of providing good utility service at negotiable cost which would not be the case otherwise with a scattered population in an area where there were quite a number of small villages quite separated from each other.

The development of suburban areas has become an important item in our national life during the post-war period with its modern facilities for transportation by motor vehicles over a well-developed system

[1] Consulting Engineer, New York, N. Y.

of highways. It affords relief for the congested population which has lived during several generations in old-fashioned, insanitary tenement houses in our large cities. It is not only better for the people themselves but tends to relieve metropolitan communities of burdensome problems of providing some of the modern facilities necessary to satisfy a substantial portion of their citizens.

Boundary lines separating various political sub-divisions of our country were not a handicap in the earlier days of our national development but at present they come up to bother us in matters of administration and financing.

Overlying municipality. It is helpful to set up an overlying municipality or political sub-division of a state, giving it jurisdiction ordinarily provided by charters and other legislative acts to towns and cities in respect to certain specific items. By this means administrative authority is concentrated and responsibility is fixed. This permits comprehensive planning on a long term basis for areas with detached and small centers of population and permits the progressive installation when and as required of coördinated facilities as to type, location and capacity. A continuing policy is thus secured in line with a financial program for putting designated services on a self-liquidating basis.

Comparison with old procedures. The creation of a district for joint undertakings is a great improvement over the old procedure where long delays occurred before tiny villages dispersed throughout rural areas could advance to a point where they might secure modern facilities as to sanitation. Changes in personnel, lack of appreciation of modern facilities and absence of adequate comprehensive planning have proved serious handicaps in the suitable development of villages and rural areas, particularly in the neighborhood of large towns and cities. Immediately adjacent areas have of course been developed by subdivisions annexed to the neighboring town or city but even under these circumstances there has been a vast amount of lost motion and misfit planning with considerable work having to be done over again after annexation takes place. These matters can be controlled under some conditions but by no means all.

The financial aspects are important because the cost to the individual in a small village is likely to be much higher for modern sanitary facilities than when they are provided by a district project. The upshot of all these things is slow progress in the adequate development for suburban areas of water supply and sewerage systems under

local control. Not only are results slow in coming and expensive but they are less satisfactory in various ways. From the administrative standpoint attention may be called to the benefits which come from district undertakings in respect to eliminating pollution of streams and of the local nuisances associated with the absence of sewer systems and the opportunity for transmission of disease by flies.

Control of pollution is frequently far more effective through the development of adequate local agencies than by orders from a state department of health through efforts to enforce provisions of public health laws founded on the police functions of a sovereign state. While it may not be true in Maryland there are some states where sewage disposal betterments are still being retarded by the requirements of public health laws that state authorities have to prove *"actual"* injury rather than *"potential"* menace to public health and property. Lack of local appreciation and initiative as to remedies frequently causes a situation to spell delay either through procrastination or the formalities of litigation in courts of original jurisdiction and appeals from decisions thereof.

The Washington Suburban Sanitary District shows a way to set up authority and responsibility in the communities involved for making remedies which it is cumbersome for state health authorities frequently to bring about.

Methods of financing. The best thing that can be said of the method described by Mr. Hall is that it is practical and effective. It makes the services provided self-supporting or self-liquidating. It provides that capital charges shall be met to a slight degree by taxation but chiefly by assessment and that the costs of operation and maintenance for both waterworks and sewerage systems shall be met by a service charge based on metered consumption of water. This is fair.

It is interesting to note

(a) that the bonds are guaranteed as to principal and interest by the County Commissioners of the two counties and that all property within the Sanitary District is subject to taxation for payment of the bonds and that the District as a whole is primarily liable for their payment;

(b) that of the District Commissioners two are appointed by the County Commissioners of the respective counties upon recommenda-

tion of the State Department of Health and that the Governor appoints the third, all for four-year terms;

(c) that the Commission issues its own bonds without referendum vote but with the approval of the State Public Service Commission which is authorized to review rates of charges for the services rendered by the District if appeal should be taken to it;

(d) that the right of the Commission to increase assessments has been adjudicated by the court of last resort.

The 65,000 people living in this Sanitary District are able to secure satisfactory service at costs which are obviously deemed reasonable by those who benefit from the service and at prices which are no doubt lower than would have been the case if even roughly approximate service in point of quality had been attempted without the formation of this overlying municipality. The growth of the district is indication that the service is considered to be worth its cost. All district costs are segregated so that the citizens can know definitely what is the allocation of costs for water supply, sewerage and sewage disposal. Thus it is necessary for bookkeeping allocation of costs of these public utilities in this district to be complete and unmixed with either credit or debit items related either to service to others or income from general tax sources. The undertaking stands on its own feet and is made self supporting which is an item of importance not only to the citizens but to the owners of district bonds.

Scope of service. It is interesting to note that plumbing is placed under the Commission's supervision and all work must be installed in accordance with its regulations. It would be interesting to learn how far this has actually succeeded in eliminating ground water leakage from house connections built inside the property lines and the inflow into the sewers from cellar drains, roofleaders, etc.

It is especially noteworthy that among the duties of the Commission is the collection and disposal of garbage and refuse and the construction and operation of a system of storm drainage whenever local conditions should so warrant.

Obviously much practical wisdom has been displayed in developing the legislative acts under which this Commission operates as well as on the part of the Commission itself and its engineering advisers in planning, financing, building and operating the District works.

PRESENT STATUS OF MUNICIPAL WATER SOFTENING

By Charles P. Hoover

(Chemist in Charge, Water Softening and Purification Works, Columbus, Ohio)

About twenty-five years ago when water softening was first given serious consideration by municipalities, there was little in the way of precedent to follow. A number of industrial plants were softening water for boiler feed and laundry purposes, but these plants were small and the water was not used for drinking or general domestic purposes. The chemicals used in the treatment of these industrial water supplies were lime and soda ash. Zeolite softening on a commercial scale was unknown at that time. The first municipal water softening plants were, therefore, designed to use lime or lime and soda ash as the softening reagents.

The process then used and still in use to some extent, by industry, in its simplest form is known as the batch or intermittent system; it consists of adding and mixing with a known quantity of water weighed amounts of lime and soda ash in sufficient quantities to react with the hardness salts in the water. This procedure results in the formation of a precipitate which settles readily and is periodically run to waste. In many cases the settled, practically clear water may be used directly; if more clarity is desired the settled water is filtered. The early filters were usually made of excelsior, but these have now been replaced almost entirely, with sand filters. This simple procedure of softening water developed into the continuous type plant. This development made it feasible and economical to build large softening plants because high capacities can be obtained with much smaller settling tanks than those required in the intermittent or batch system.

Although the cost of building softening plants was materially reduced by building plants of the continuous type, the water was not always as satisfactorily treated, because (1) if water is pumped to a plant continuously it is not possible to pump it at an exactly uniform rate without special equipment; (2) it is more difficult to apply

chemical reagents uniformly and continuously over a period of a number of hours than it is to weigh it out as a batch and apply it all at one time.

There has been a disposition to emphasize the errors made in the dosage of water softening chemicals and many of these errors can, without doubt, be attributed to the inadequate facilities that have been provided in the past for measuring water and applying chemicals to it.

ADVANCES IN WATER SOFTENING

The successful application and wide-spread adoption of the lime soda ash process of softening municipal water was not accomplished until about nine or ten years ago. However, during the past decade, over one hundred municipal water-softening plants have been built. In the state of Ohio 53 water treatment plants have been built during the past nine years. Thirty-four of these are lime or lime soda ash softening plants and 7 zeolite softening plants. Four are for iron removal only and 8 for filtration only. Twenty-two of the lime softening plants have been built in the last 4 years and 6 of the zeolite plants in the last 4 years. Nineteen of the 34 lime soda plants soften well water, 5 soften both well and surface water and 10 soften surface supplies. Between the years 1920 and 1925 many improvements and refinements were made in the lime soda process for softening municipal water supplies. The improvements and developments have previously been described (1) under the following chapter headings. 1. Handling of Chemicals; 2. Mixing Devices; 3. Clarifiers for Continuously Removing Sludge; 4. Methods for Further Reducing Hardness; 5. Substitution of Zeolite for Soda Ash to Remove Non-carbonate Hardness; and 6. Recarbonation.

LIME SODA SOFTENING PROBLEMS

Incrustation of sand filters. If lime settled water is carbonated to a pH of 8.4 to 8.6, there will be little or no incrustation of the sand in the filters. Calcium carbonate however, is least soluble at a pH of about 9.4, therefore, by carbonating to this point only, it is possible to remove by filtration the colloidal calcium carbonate formed after recarbonation and thus obtain lower alkalinities than would otherwise be possible. It is considered advisable by almost all softening plant operators not to carry the recarbonation below pH 9.2 to 9.4. Consequently, unless large settling basins are available in which the

colloidal precipitates may crystallize and deposit, they are removed by filtration and this causes some incrustation on the sand. It should, however, be possible to operate filters, filtering water carbonated to pH 9.2 to 9.4 for from 12 to 15 years before it becomes necessary to replace the sand or other filter medium. The question of the entire elimination of incrustation of filter sand in lime softening plants, is being given thought and study and like the depression, its solution seems to be just around the corner.

Disposal of water softening sludge. The disposal of water softening sludge may or may not be a problem. A softening plant located near a sizeable stream or having available, nearby low ground to be filled, can easily dispose of it. Very small plants can lagoon it, let it dry and give it away to farmers or gardners to be used for land treatment. On the other hand, if there is no available place to put the sludge, its disposal may be the determining factor as to whether or not this type of softening plant should be built. The following methods for disposing of sludge have been used:

1. Discharge into streams directly.
2. Store and discharge into stream during high water.
3. Discharge into abandoned reservoirs or quarries or onto low ground.
4. Discharge into City sewers.
5. Dry and use for liming soil.
6. Reburn into lime.

Discussion of these various methods will be found in the Ninth and Eleventh Annual Reports of the Ohio Conference on Water Purification.

Requirements of a lime soda softening plant. Modern lime or lime soda water softening plants should be designed (1) to require a minimum amount of labor in their operation; (2) to be practically dust proof; (3) to provide for an accurate and uniform application of the softening chemicals, thus insuring a minimum of variation in the hardness of the softened water; (4) to make possible the reduction of hardness to practically the theoretical solubility limit; (5) to produce water in chemical balance and thereby eliminate the building up of incrustation or deposits in the distribution system, or red-water troubles in hot water heating systems (2). A modern lime or lime soda softening plant should also be capable of softening muddy water as successfully as clear water and should eliminate entirely from the softened water, all turbidity, practically all color,

free carbonic acid, iron, manganese, hydrogen sulfide, harmful bacteria, objectionable tastes, and odors.

ZEOLITE SOFTENING

Original water softening zeolites, introduced into this country about 1911 or 1912, although of comparatively high capacity, were low in rate of activity. They were slow in softening, and long periods of time were required for regeneration. They were also inefficient in salt consumption, using from two to three times the amount of salt required with the modern rapid zeolites. The modern zeolites are greensand, found in extensive deposits in New Jersey and elsewhere, and, the more recent gel types.

Previous to 1925, the use of zeolite water softening was almost entirely confined to domestic and industrial installations. Since that time about 28 or 30 municipal water softening plants of the zeolite type have been built. Seven of these, as has already been stated, are in Ohio.

Modern zeolite plants should be built to produce the same quality of water as is expected from a lime or lime soda treatment plant.

Early zeolites. The early zeolites used commercially for water softening were prepared by fusing materials containing alumina, and silica with an alkali. The fusion so obtained resulted in a glassy melt, which was crushed, washed, ground and graded to proper size. This material was hard, granular and was reported to have had an exchange value of from 4000 to 5000 grains of hardness (terms $CaCO_3$) per cubic foot. Its action was slow and water softened thus had to be passed through slowly. It also regenerated very slowly, regeneration being a matter of hours rather than instantaneous as with zeolite now used, and it also required more salt than present day zeolites. Fused synthetic zeolites were largely supplanted by greensand and the synthetic gel types of zeolites. Both act quickly and can be regenerated quickly.

Greensand zeolites. Deposits of greensand zeolites are found principally in New Jersey. As it is dug from the pits it contains about 40 percent of impurities or waste products which must be removed before it can be processed into a granular greensand suitable for water softening. Even after being washed and otherwise treated to remove the impurities, the sand is not yet suitable for water softening because it is not hard enough to withstand the friction of water passing through it and must be hardened or stabilized. It

weighs from 90 to 100 pounds per cubic foot. It is estimated that the supply is practically inexhaustible. There are twenty-three patented processes for stabilizing or hardening greensand.

Synthetic zeolite (gel type). Synthetic zeolites of the gel type are manufactured by the precipitation or so-called wet process. They are made by producing a gelatinous precipitate or jelly from material containing silica, alumina and alkali. This jelly may be made from solutions of sodium silicate and sodium aluminate or from sodium silicate and aluminum sulfate. The precipitated jelly is dried, broken down into small lumps and granulated in water, after which the soluble salts are washed from it. The grains are white and very porous but hard and after proper screening are ready for use in softening hard water. Synthetic zeolite weighs about 50 pounds per cubic foot.

Softening capacity of zeolites. Generally speaking, one cubic foot of greensand will remove from 2800 to 3000 grains of hardness before it needs to be regenerated and gel type zeolite will remove from 9000 to 12000 grains. Softening capacities are less if the water being softened is excessively hard or if it contains large quantities of sodium salts. The capacity of synthetic zeolite is also less if the water being softened contains an excess of mangesium hardness. Compensation for softening capacity must therefore be made for excessively hard water and water containing large quantities of sodium salts. The size and number of softening units required per unit of water softened depend on the hardness of the water and the frequency of regeneration. A plant, for instance, where the units are regenerated every eight hours will be just twice the size of a plant with units which must be regenerated every four hours.

Salt requirements. Generally speaking, from 0.4 to 0.5 pound of salt are required for each 1000 grains of hardness removed. The salt at municipal plants is usually stored in a two compartment concrete bin. Usually each compartment is built to hold at least one carload of salt. Salt weighs approximately 60 pounds per cubic foot therefore to hold 30 tons the bin must have a capacity of at least 1000 cubic feet. The bottom of the bin is usually hopper-shaped. The lower part of the hopper forms a reservoir or collecting trough over which is placed a screen or perforated plate (preferably made of non-corroding material) covered with about one foot to eighteen inches of graded gravel $\frac{1}{4}$ to 3 inches in size. The salt is usually shipped in box cars in bulk and is shoveled from the cars

into the bin. It is customary to build the bins out in the open and as near the railroad track as possible; therefore they are built so that the top is just a little above the ground level. They may be either open or covered. After the salt has been placed in the bin it is covered with water. The water dissolves the salt giving a saturated brine solution which passes through the gravel into the collecting reservoir. In a single-compartment bin this reservoir is usually built large enough to hold enough saturated brine to regenerate one softening unit. In a double-compartment bin the saturated brine is usually carried to a brine well, located between the two compartments. From the brine well or the collecting reservoir, as the case may be, the brine flows or is pumped to a measuring tank where it is diluted to about a 10 percent solution, and from the brine measuring tank it is applied to the softening unit.

Salt saving scheme. The first quarter or the first half of the regerating solution undoubtedly removes a large percentage of the calcium and magnesium and a scheme for segregating into various portions the emerging salt solution and using over again the less contaminated portions is the basis of U. S. patent No. 1,510,569. No municipal plants at the present time are equipped with salt-saving devices.

Automatic regeneration. One municipal plant that has been built, is equipped so that each unit is automatically regenerated after each two hours of operation. The regeneration periods are made on short frequency intervals, therefore, large quantities of water can be softened with relatively small units.

Testing zeolites and methods. There is no test or set of tests developed at the present time that will reveal the durability of zeolites over a long period of time. However, there are important physical and chemical characteristics that can be determined by simple laboratory tests. The results of these tests show the relative porosity, the exchange value, the grain size, percentage of fines, powdering action of water and quantity of humus or soft material present. Standard tests are being prepared by a committee appointed by the President of the Water Purification Division of the American Water Works Association.

ZEOLITE SOFTENING PROBLEMS

Control of hardness. In operating a zeolite softener, zero-hardness water can readily be produced. The water softened by municipali-

ties, however, is used for all purposes and it seems inadvisable to soften an entire supply to zero hardness. A considerable saving in the cost of operation can be made if the hardness is allowed to rise to from 50 to 70 parts per million; in other words, from 3 to 4 grains per gallon, and it is, we believe, also necessary to leave some hardness, that is, calcium carbonate hardness, in the water so as to prevent it from being corrosive in the distribution system. In other words, it should be in chemical balance to calcium carbonate. Well water containing iron in solution is practically devoid of oxygen but contains free CO_2. If chemical balance cannot be obtained by admixture with raw water, then the effluent from the zeolite softeners should be aerated to get rid of the CO_2 or the CO_2 should be neutralized with an alkali. It is not advisable to aerate before passing through zeolite because by aeration, iron is precipitated and is more difficult to remove in this condition than by base exchange.

The following schemes for controlling hardness of zeolite-softened water have been used.

1. Mix zero-hardness water with unsoftened water in the correct proportion to obtain water of the desired degree of hardness. This is done successfully at some zeolite softening plants, but it is not advisable when the water being softened contains a large quantity of iron; because if the raw water contains iron and a portion is mixed with the softened supply, the mixture will contain iron in direct proportion to the quantity of raw water added. Unless raw water high in iron is extremely hard, thus requiring only a small portion to be mixed with the zero water to give chemical balance, the mixture would be unsatisfactory on account of the presence of too much iron.

2. Aerate and filter through sand that portion required to be mixed with zero water. This is of course satisfactory, but it requires additional equipment.

3. Add lime to precipitate iron and settle it out before mixing with the zero softened water. Long settling periods would be required by this treatment.

4. Add lime to precipitate iron and filter through sand filters before mixing with the zero softened water. This also requires additional equipment.

5. One Ohio municipality, having a hard well water supply containing both carbonate and non-carbonate hardness and iron in solution, removes all of the iron and the greater part of the carbonate hardness from its entire supply by lime softening. This is followed

by recarbonation and sand filtration, after which a portion of this water is softened to zero hardness through zeolite. A mixture of lime-softened water and zero water is then made in the proper proportion to give the desired hardness. This process is economical because carbonates are removed more cheaply by lime treatment than by zeolites and it is cheaper to remove non-carbonates by means of zeolite. Thus each kind of hardness is removed by the cheapest known process. This process in practice is giving satisfactory results.

6. Zeolite will remove iron from water for a certain length of time, even after it has become exhausted for removing hardness and in an attempt to take advantage of this, one plant in Ohio having a hard well supply containing iron in solution was equipped with four zeolite softening units. The operation of these units was arranged so that three were softening to zero hardness and the fourth not softening but removing iron. All four discharged their effluent into the same supply reservoir. The difficulty with this scheme is that zeolites do not have a sharp exhaustion point. In other words, the hardness of the effluent from a zeolite softener does not change instantly from zero to that of the raw water supply, and therefore it was found difficult to maintain uniform composition.

Dissolving iron from distribution system. Water containing free carbon dioxide and being free from iron and oxygen will readily dissolve precipitated iron or iron nodules already formed in a distribution system. Highly carbonated, oxygen free well water pumped through zeolite softeners may be entirely free from iron as it leaves the softener, but if pumped through an already corroded distribution system, the immediate results will not be satisfactory to the water consumer and presumably will not be until after all the rust in the distribution system has been dissolved or washed out. However, if the water is aerated and the pH and the calcium carbonate balance are adjusted, almost immediate satisfactory results should be obtained.

CHOICE OF PROCESS

The choice between lime or lime soda ash, greensand, or gel type zeolite for municipal water softening, is one that requires careful consideration in each individual case.

Applebaum (3) listed the considerations in favor of municipal zeolite water softeners as follows:

1. Absence of any sludge.
2. Low initial cost.

3. Low operating cost.
4. No danger of excess of chemical being present in the effluent.
5. Zeolite plants operate without difficulty, even though water supply changes in composition.
6. No possibility of after reactions to cause deposits in the distribution system is possible with zeolite treated water.
7. The mechanical problem of handling and feeding multiplicity of chemicals including problem of dust prevention, is avoided.
8. Unskilled labor may be successfully employed in the operation of zeolite plants.
9. Hardness of effluent may be as low as desired.

He listed the considerations for municipal lime soda treatment as follows:

1. Suitability for turbid waters.
2. Lower total solids in effluent.
3. Corrosion prevention

In the discussion of this paper, A. S. Behrman (4) expressed his enthusiasm for zeolite softening, but expressed the belief that Mr. Applebaum had gone entirely too far in painting a picture of a zeolite water softener as an ideal of simplicity and fool-proof efficient operation, and, in contrast, a lime or lime soda installation as rather a hazardous enterprise to be undertaken in comparatively rare cases and only when skilled chemical supervision is continuously provided.

He further said that the choice between the two types of softening as applied to community water supplies is really more of a 50-50 proposition with the odds, if anything, in the majority of cases, in favor of lime treatment.

No intelligent choice can be made between the two processes unless the following information is available:

1. Is there a place available for the disposal of sludge?
2. Is the water to be softened always clear or is it sometimes muddy?
3. Is the water safe bacterially?
4. What is the analysis of the water? Is it excessively hard? Does it contain large quantities of sodium salts? Is the proportion of magnesium hardness excessive? What percentage of the hardness is carbonate and what percentage non-carbonate? Does it contain silica, high free CO_2, iron, manganese, or hydrogen sulfide?

5. Cost of salt, lime, and soda ash.
6. Is the supply of available water scarce, or abundant?

If there is no place available or method provided for disposing of sludge, then it would, of course, be unwise to build a lime-soda plant.

If the water to be softened is turbid then the chances are that a lime-soda plant can be built much more cheaply than a combined filtration and zeolite softening plant.

If a water supply is not safe bacterially the bactericidal value of lime treatment renders the lime softening process suitable for correcting this condition.

Many water supplies have wells that are badly located with reference to sewers or other sources of contamination. The casings may be badly rusted and leaky. For such wells the lime softening process is particularly suitable.

The effect of excess hardness, magnesium, and sodium salts on the zeolite capacities have already been stated.

The cost of operation, of a lime-soda softening plant depends on the character of the hardness. Bicarbonate of calcium, for example, is removed much more cheaply than bicarbonate of magnesium and the bicarbonates are removed much more cheaply than the sulfates, chlorides and nitrates.

The cost for lime to remove bicarbonate hardness, under normal conditions, is about one-half the cost of salt. On the other hand, the cost for salt to remove non-carbonate hardness under normal conditions is about 20 percent less than the cost of soda ash. Generally speaking, the lime treatment has two advantages over zeolite for softening bicarbonate hardness water. First, the chemical cost is less and second, the total solid content will be less. The adoption of the zeolite process has been urged for the softening of water high in carbonate hardness and containing large quantities of sodium bicarbonate. In view of the fact that lime treatment alone will produce an almost ideal water from such a supply and do so at such a small cost there should not be much argument about its selection.

Zeolite is to be preferred for water containing non-carbonate hardness provided it is clear and does not possess unusual characteristics, because the cost of operation will be less, the initial investment will be less, there will be no sludge and operation will be simplified. Even though the cost for salt and rinse water does exceed the cost of lime and soda ash, many small communities would still be justified in installing zeolite softening on account of the advantages enumerated above, but this would not necessarily be true for sizeable plants.

Several water supplies in Ohio contain so much iron that aeration and sand filtration will not remove it. Water of this kind cannot be softened by zeolite. It requires lime treatment to remove the iron as well as to soften it. The presence of iron or manganese or both presents no problem if the lime or lime soda ash process is used. They are precipitated along with the calcium and magnesium and help rather than retard the functioning of the process. These compounds must be given consideration if zeolite is used.

The quantity of wash and rinse water required in the zeolite softening plants ranges from 5 to 25 percent. If the water supply is limited this feature must be carefully considered. As the water softened increases in hardness, the percentage of washes also increases. Wash water is based on the rate of wash per square foot per minute. High-capacity minerals such as the synthetic gels require less wash water per unit capacity than greensand, because the area of the softener is less. Deep beds of zeolite also require less wash water per unit capacity than shallow ones, because here again more water can be softened per unit of area. The depth of the mineral in some plants has been made over six feet.

Greensand zeolite is usually preferred when the water to be softened contains appreciable quantities of iron or when it is deficient in silica.

Synthetic gel type zeolite is usually preferred for water low in iron or water that has been sand-filtered preparatory to softening, because smaller units are required and less wash water is needed.

(Presented before the Wisconsin Section meeting, October 12, 1932.)

REFERENCES

(1) Journal American Water Works Assoc., 20: 5, November, 1928, page 642.
(2) 9th Annual Ohio Conference Report, page 96.
(3) Journal American Water Works Assoc., 24: 9, September, 1932, page 1364.
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HANDLING DELINQUENT ACCOUNTS

By Carl K. Chapin

(Commercial Director, Department of Water and Power, Los Angeles, Calif.)

The value of a paper dealing with collections should primarily be gauged by the success indicated in making collections, and in addition by a recognition of the extent to which desirable public relations are maintained. Economies of course have much significance in the purported success of any plan for collections.

The Department of Water and Power of the City of Los Angeles, in its collection methods, does not receive the same advantages as do many cities, because there is no California State law whereby water bills are made a lien against property. With cities thus fortified the matter of collections is greatly simplified. Even without this protection, it may develop that a smooth-running and aggressive follow-up system will bring in the revenues at an earlier date after billing. With such a law the losses chargeable to uncollectibles are practically none. However, it may develop that over a period of time, the cyclic flow of incoming revenues safeguarded by such a law, will offset any advantage of quicker return of revenues, as between billing and payment dates, afforded by the close follow-up system.

The advantages to be gained by such legal protection of revenues are manifold. First, the possibilities of engendering and maintaining pleasanter relations with the public—a matter of paramount importance in these days of high competition—is of equal importance with the amount of revenues collected. Further, under certain circumstances a greater extension of credit may be permissible with less apprehension of ultimate loss. Consumers will appreciate this extension of credit, even at the same time realizing that payment will eventually be required. During a time of financial stringency, even though the water bill may be among the smallest items in the household budget, by the privilege of postponement of payment where necessary, much good will is engendered and the ever-apparent needed

support of a public utility is given more graciously by those to whom this courtesy has been extended.

The water rate ordinance of the City of Los Angeles, now in effect, reads in part as follows:

> All meter rates are due and payable on presentation of the bills. A cash deposit or other evidence of sufficient credit . . . . to guarantee payment of bills, may be required at any time in an amount not exceeding the charges for the estimated quantity of water consumed in two months provided that no deposit shall be less than Three Dollars.
>
> Bills become delinquent fifteen days after presentation and if not paid the water may be shut off without further notice.

While our water ordinance does not specify from whom we shall require deposits, our practice is to waive the deposit where service is contracted by the owner, except when owner has for reason been given a poor credit rating, or where contracted for with a tenant with the owner signing as guarantor.

Tenants signing for service are required to give a cash deposit as outlined in the ordinance.

Operating from this basis a consumer's account progresses toward collection substantially, as follows:

Fourteen days after mailing the bill, if unpaid, a post card known as a "courtesy notice" is mailed, which is in no sense a duplicate bill but simply recites ordinance requirements in the payment of bills. The purpose of this card is primarily to bring to the attention of the consumer, who has overlooked payment, that the bill is due and payable. Further, by its continued use consumers become familiar with ordinance requirements. On the whole, it tends to lessen the days between the mailing date of the bill and the date of payment. On the other hand, in some cases it acts in the opposite direction, causing some consumers to wait until they have received this notice before giving any attention to the payment of their water bill month after month. And again, consumers habitually prompt in settlement of their bills upon once overlooking payment and receiving this notice, take exception by interpreting it as a dun, and as a reflection upon their credit and general standing in the community. Rather vigorous exception is taken at times on this account. The courtesy card has however received the approval of the post office department as to terminology, and when mailed as a post card fully complies with postal regulations.

The general effect of this card immediately after its being mailed

is reflected by a sharp upturn of our collections, after a steady downward trend between the date of mailing of the bill to the mailing date of this notice.

All accounts unpaid five days after mailing of this card are given to field collectors, and in theory, collection is effected by them or service discontinued. This is so "in theory" as in better times the rule is absolute, concessions only being made for variance upon presentation of circumstances mitigating to the extent as dictated by common sense and judgment, in which case a further extension of time for payment is granted. During the present stress further time is granted for payment of the greater number of accounts reaching the shut off period and a close follow-up is kept in accordance with the agreement reached between the consumer and the field collector.

Where collection is not effected after the usual number of calls and shut off has been necessary, the account is carried into an uncollectible bills ledger for a period of three months during which collection effort is continued. At the end of the three months' period, providing collection has not been made, the account is charged off as uncollectible and placed in a dead file only to be revived upon relocating the consumer at another location. This is accomplished by checking names on new contracts against this dead account file.

While the plan outlined is to a great extent automatic in operation and provides for a rapid and efficient method for the collection of revenues, and is designed to afford the maximum in desirable public relations, it is at the point where the human element is of necessity injected into the plan that difficulties begin which cause collection costs to increase to an amount approaching the money value of revenues collected. It is generally agreed, however, that such expenditures are justified in adhering to established businesslike practices, even to the extent that the expense involved sometimes exceeds the revenues received.

RESULTS IN LOS ANGELES

The following statistical data reflect the results obtained in the Department of Water and Power of the City of Los Angeles:

Approximately 430,000 regular bills are rendered each month, and of this number all but some 150,000, or 35 percent, are paid at the end of fifteen days. At the end of thirty days 7 percent or 30,000 accounts are still unpaid, and all of these items become carry-over or balance items of the previous month. During a period from 25 to 55

days after rendering of bills there are approximately 2,000 accounts shut off for non-payment or less than one half of one per cent. Of these 2,000 accounts shut off two-thirds of them are settled and service restored.

Out of 2,500 accounts passing to the uncollectible ledgers less than one per cent are collected during the ensuing thirty days. Of all bills passed to these ledgers 65 percent of the total amount represented is borne by 25 percent of the total number of bills. Of these 20 percent of the amount of money represented is ultimately collected before they are finally written off to bad debts. Over a period of years the amount of money reaching our bad debts account has approximated between one quarter and one third of one percent, and while these percentages may appear under the circumstances, quite low, they are the results of a closely connected follow-up system at certain stages of which it may be seen to represent expense outlays unjustified by revenues gained. Ever to be borne in mind, however, is the value of establishing businesslike handling of such matters in the eyes of our consumers, who are in effect the owners of our municipal system.

During the steady progress of this collection routine, the matter of continuing desirable public relations is ever present, and with the many siftings of our accounts, the time arrives when individual cases are handled strictly on the merit of the circumstances surrounding each case. The injecting of the human element, and in many cases the humane element, into the work, we believe to be necessary for obvious reasons, some of which have been recounted.

In the handling of closing bill collections, of an average of 15,000 rendered monthly, of which 10 percent to 15 percent come into being through the enforcement of city ordinances and 85 percent to 90 percent upon request of consumers; 50 percent are paid within the succeeding 10 days, with 40 percent of the balance being taken care of within 15 days. Of the residue approximately 20 percent go beyond the 90-day collection period and are transferred to our uncollectible ledgers, there to be administered as previously outlined.

With us, as with all utilities, the matter of collection of closing bills requires a greater expense outlay per transaction than is required for the great volume of current accounts. This statement bears out the fact that collection costs are held to the minimum in proportion to the degree that the procedure becomes automatic, with unit costs per collection being lowered in the ratio that successful handling of closing

bills bears to the total job before us. The guarantee afforded where a State law is effective, should in the opinion of many permit lower unit costs than where such operation is not so protected.

We believe our plan has proved its effectiveness in season and out of season, by the actual revenues collected, by its simplicity of operation, by a lowered unit cost per collection, and, finally, by its acceptance on the part of the public as reflecting good businesslike management of a municipally-owned utility.

In California our utility bills are outlawed at the end of four years, unless change is made in their character, that is, from a current or open item on our books to a judgment obtained by process of law. Upon receiving the latter status they stand as legally collectible for five years, subject to certain general privileges of extension or renewal of judgment by additional court action. (California Code of Civil Procedure, Sections 336, 337 and 685).

In the handling of the "unusual" case, where the human factor is predominant, a successful effort can only be guaranteed by the degree to which personnel have been trained to analyze given situations. This part of our operations frequently requires close cooperation between collectors and the administering head of a division.

At times a situation develops which passes entirely beyond the collector's province to affect satisfactory adjustment. While these cases are few they are essentially important for the reason that possible damage done by improper handling of a critical situation is far-reaching in its reflection upon the integrity of the Department and its management. Good practice would seem to dictate that delegating rather extensive authority to collectors in the field and at the office counters, as well as to their immediate supervisors, is desirable and necessary. At the same time the officer in general control of commercial work must assume responsibility in connection with these "unusual" individual cases, as well as for the successful operation of the division as a whole.

By way of relating some of the history of California municipalities with reference to the plan of *dealing with property* rather than individuals whereby unpaid water bills are considered as a lien against property, it may be of interest to know that a rather extensive study brings forth the information that we have eighteen cities, ranging in population up to 50,000 inhabitants, reporting that this lien provision is embodied in their rules and regulations with more or less effectiveness. As to the constitutionality of such a provision, we have knowl-

edge of one case where an incoming consumer was refused service pending settlement of an unpaid account left by an outgoing tenant. The lower court's ruling was in favor of the plaintiff and service was ordered turned on for the benefit of the incoming tenant. Appeal was not taken even though the city ordinance carried a provision that unpaid water bills would operate as a lien against the property served.

The State of Rhode Island, through its Attorney General cites their statute which definitely provides that unpaid water bills "shall be a lien . . . . in the same manner as taxes assessed on real estate, ... and if not paid as required . . . . shall be collected in the same manner that taxes assessed on real estate are by law collected." The states of Wisconsin and Nebraska also have statutes which, in effect, carry the same authority. There are other states where the status of a municipally-owned utility is classified with the privately-owned utilities insofar as responsibility for rendering service to the public is concerned. Some states hold as constitutional the right of a municipality to adopt rules and regulations governing their municipally-owned utility which affords the same protection in the matter of collections as provided by statute in Rhode Island, Wisconsin and Nebraska.

May I refer to an article[1] published in The Journal, by Hal. F. Smith of the Detroit Department of Water Supply, wherein statement is made that "water accounts in Detroit are not accounts with certain individuals but *with legally described pieces of property*, either the tenant, owner or agent may pay the bill." Further on at page 377, under the heading of Discussion, a representative from Ohio makes the definite statement that in his State "accounts are with property. We send bills to anyone requesting them. If not paid by tenant we change it to the property owner. Water debts are not registered. If the property changes hands the respective buyer checks up all taxes and water rates against it." Again, at page 381 a Pennsylvania representative states that "in Erie a water bill is a lien against the property. We bill the owner and refuse to send the bill to the tenant. Our losses are practically nil."

From the foregoing it would seem that this is a matter which has received a great deal of thought in many quarters. In some, legal provision has been made. Results obtained appear in direct ratio

[1] Journal, March, 1930, page 372.

to the extent to which these protective measures have been administered. In California, where water is always a problem, it does seem that all possible assistance should be accorded utilities to guarantee collection of revenues as capital outlays are correspondingly higher than in localities blessed with an abundance of water, readily procurable.

(Presented before the California Section Meeting, October 26, 1932.)

OWNERSHIP OF CONNECTIONS FROM WATER MAINS TO PROPERTY LINES

By W. S. Vrooman

(Manager, Commonwealth Public Service Company, Deer Lodge, Mont.)

This is the case of an orphan, a waif of the streets and alleys whom nobody cares to claim or protect. In fact, Mr. Consumer or Mr. Supplier are continually attempting to abandon this outcast upon the other fellow's front doorstep, but he usually receives a bucket of cold water for his pains. I have been asked to pose as both accuser and protector of this poor object of public neglect.

The question of ownership of service lines from the mains to property line has created in many instances a "no man's land" of the parking strip in which the consumer and city or company often meet in conflict from which the latter may easily emerge, without the exercise of tact and sound sense, the loser regardless of the outcome. I mean the loser in the sense of "goodwill."

To the consumer it is a senseless condition that he must own and maintain a part of the system which is serving him with a commodity for which he is charged. Further, it is doubly incredible that he must install and maintain a part of this structure on property which he does not own. He argues that it would be as sensible for him to build his home upon land which was owned by another.

To the plant operator the same financial difficulties appear which are stressed by the consumer, only magnified by the number of names he has in his ledger. Must he capitalize thousands of dollars worth of black iron or corroded and undersized service lines of whose age or physical condition he has little or no knowledge? What of the additional maintenance charges? Will the consumer take gracefully to a possible rate increase involved by saddling the company or city with this added responsibility and expense? The operator argues that parallel, and sometimes too close to the service lines, lies the sewer lateral in nine cases out of ten owned by the property owner. There is little or no controversy over the ownership of the sewer lateral. Why all the furore about the service line?

In an effort to obtain a cross-section of opinion on the subject questionaires were sent to about 80 operators of plants serving towns of 400 population or over in the State. Only 10 replies were received and it is suspected that about 75 percent of those not replying might be placed in the category headed by one reply as follows: "Why bring that up?"

To operators and managers of long experience in the State the following data are probably old, but for the sake of presenting the evidence the answers to the questionaires are tabulated as follows:

(1) Are services corporately or privately owned?
Corporate—None.
Private—10.
(2) Which are favored?
Corporate—One to curb at least.
Private—8.
No Choice—1.
(3) Do you favor corporate ownership to the property line?
Opposed—9.
In favor—1.

In most cases where corporate ownership was opposed the reason advanced was additional expense of maintenance which must be absorbed by the consumer and the necessary readjustment of the rate structure to absorb this maintenance with consequent dissatisfaction on the consumer's part. From a financial standpoint this condition was expressed in one case by a non-committal as to choice between private or corporate ownership "for" as the reply read: "The consumer ultimately pays the bill anyway."

From the foregoing meager statistics, if they may be taken as fairly representative of existing conditions in the State, services are to a very large extent or wholly privately owned and operators in general, if not in favor of existing conditions from an engineering standpoint, at least have expressed themselves as being opposed to any change which would burden them any more financially than they are at present.

GENERAL PRACTICE

So much for a close-up view of our local conditions and policies. What are the views of others in the country who have given the question some thought?

Of 30 replies to the question put in "Water Works Engineering" 90 percent were in favor of company or municipal ownership, from

the main to the curb, but almost without exception these same men expressed the opinion that the consumer should bear the initial expense of installation either in full, on a flat rate basis, or on a percentage of the cost, and all accepted as a matter of fact the effect upon rates based upon an increased capitalization.

The reasons advanced for the above general point of view were as follows:

(1) Uniform installation as to depth, location and materials.

(2) Company or municipal responsibility and immediate repairs in case of a leak between the main and property line.

(3) Centralized responsibility in case of pavement repairs and replacements. (Property owners and plumbers are slow to make repairs and hard to hold responsible in case of defective work.)

(4) Satisfied consumers with elimination of arguments between consumer and operator as to responsibility in case of repairs.

(5) In new improvement districts all services may be laid prior to pavement and thus eliminate the necessity of tearing up pavements later to lay services.

(6) The consumer pays the bill anyway.

Opposed to these arguments and meriting serious consideration in weighing the problem are the following reasons for private ownership which are perhaps just as convincing.

(1) Inasmuch as the company or municipal organization is governed by their own, or franchise requirements as to depth, location and materials for mains, would it not be as logical to regulate the laying of service lines accordingly? This is actual practice in many instances.

(2) In case of leaks between the main and the property line on privately owned services, the proper procedure is generally or can be quite clearly outlined in regulatory commission rules and regulations. Any laxity as to the prosecution of repair work is then strictly up to the company or municipality as much as it would be with corporately owned services.

(3) Pavement repairs and replacements should in any case be the work of the City or operating company, whether the service be privately owned or corporately owned, and the bare cost of labor and materials charged to the consumer.

(4) If the same rules as to installation and materials were applied in the case of private ownership as are proposed for corporate ownership, the elimination of cause for complaint of poor service would be

as effectively stopped. Furthermore, unless services of suitable material and workmanship were laid all the way to the premises such cause for complaint as lack of volume due to corroded lines and discontinued service due to freezing would not be eliminated.

(5) If in new improvement districts a service is laid to every lot to forestall the necessity of removing pavement later, what of those services which are not used for a period of years or perhaps never? By the time they are used they may have depreciated beyond use in certain soils. What of the capital outlay lying idle? Is the added expense to the consumer justified?

(6) And again the argument: The consumer pays the bill anyway. This last remark seems to be the ultimate connecting link between all arguments pro or con on the subject.

It all boils down to the one or two questions. Is the consumer going to be content to be burdened with a higher water rate or perhaps a surcharge, or if given the opportunity to decide for himself would he prefer to assume the initial expense of installation and the consequent maintenance cost? Furthermore, what will his reaction be to the man next door who through negligence or faulty construction of his service line on his premises has frequent freeze-ups and is the direct cause of higher production costs if the company does the thawing, and consequent higher rates? Shall we answer this question by placing all thawing operations in the hands of local plumbers and the individual charge to the consumer? Are all the plumbers competent to carry on thawing operations without injury to the service line?

Apparently the question become distinctly divided into two issues. First, the technical and engineering phase which from the side of the operator seems to justify corporate ownership, and, second, the financial phase which it would appear should be decided by the consumer in the light of actual facts and figures.

THE TWO-MAIN SYSTEM

A possible way out appears in the case at least of the installation of a new plant. During recent years the two main system has come to the front with increasing appeal to many operators. Consider for a moment the comparison of a new installation of a two main system with service lines perhaps two or three feet long as opposed to a single main system with service lengths dependent on the width of the street.

The following is a case cited in a recent issue of "Public Works:"

For the purpose of comparative costs we will make the following assumptions:

Width of Street	66 feet property line to property line
Lots	30 feet wide
Services	One to each lot

Total cost estimated for 1000 feet of street.

Single main system

1000 feet 6-inch C. I. main @ $1.75 per foot	$1,750.00
66-¾-inch services installed from main to property line complete with corporation cocks, curb cocks and curb box	
2178 feet @ $1.30 per foot	2,831.40
Valves	80.00
Total	$4,661.40

Two main system

2000 feet 6-inch C. I. @ $1.75 per foot	$3,500.00
66-¾-inch services 2 feet long complete with corporation cocks, curb cocks and curb box	
132 feet @ $4.50 per foot	594.00
Valves	160.00
Total	$4,254.00

Under the foregoing conditions the saving in first cost is $407.40 per 1000 feet with two mains. Had the street width been assumed as 55 feet the cost of the two systems would have been identical. Or assuming a street 100 feet wide and lots 50 feet wide, the saving in initial cost would be $140.00.

The above assumptions are general and variations may be made which would show either a greater initial saving or perhaps a greater cost, but at any rate it can be conceded that for the sake of discussion the initial cost of either system is approximately the same.

Let us see how this fits in with the question of service ownership.

(1) Uniformity of installation from the main to the property line becomes a necessity because of the nature of the main layout. The question of saving in cost by the use of cheaper service material becomes negligible because of the small total cost of all installations.

(2) The possibility of leaks in services within the street lines is

reduced to a minimum and the responsibility to the company or municipality is reduced in proportion.

(3) Pavement repairs and replacements due to faulty services are eliminated.

(4) Such an installation leaves small chance for argument between the consumer and company as to where the cause of reduced pressures and frozen lines lie and at the same time reduces the city or company maintenance charges to a minimum.

(5) The objectionable feature of laying service lines prior to paving projects in new districts is eliminated.

(6) Again the consumer pays the bill but in this case he can actually receive better service at a lower charge as far as first cost is concerned and maintenance charges to the system are reduced to a minimum.

This is an example offered as a suggestion which in itself presents its own problems of economics. The example stated is based on actual bid prices and, of course, assumes that all service connections are made at the time the main is laid. Better economics may be effected by a variation of the two main system, such as a feeder main on one side of the street and smaller so-called service mains crossing the street at intervals to a separate service system in each block.

Again, if a flat charge were made to each consumer for his service based upon readiness to service rather than actual length of service laid it would result in an original cost either to the municipality, company or consumer of no more than a single main system and would effect economies of operation which could be handed on to the consumer in return for a fair measure of good will.

(Presented before the Montana Section meeting, April 2, 1932.)

MODERN WATERWORKS PUMPING STATIONS

By William Gore

(Consulting Engineer, Toronto, Ontario, Can.)

Most domestic water supplies for Canadian cities are taken from rivers and lakes at levels too low to flow by gravity to the consumers, and pumping in some form or other has to be resorted to. While there are several types of pumping equipment which have been used for this purpose the wide and economical distribution of hydro-electric power throughout the Dominion has led to the electric motor, direct driven centrifugal pump becoming standard. Owing to occasional power failures, however, which fortunately are becoming less frequent, it is generally considered necessary to provide some form of standby pumping equipment with prime movers, such as steam engines in the case of the larger plants; diesel or other oil fuel engines in the intermediate and gasoline engines in the smaller plants. Occasionally electric generators driven by similar prime movers are provided as standby equipment, but as these supply power to the standard equipment which in itself may fail, this type of standby is not generally recommended.

The modern pumping station, therefore, invariably provides for two types of equipment, each as much as possible independent of the other. The Fire Underwriters are rightly most insistent on this principle. As both the standard and the standby equipment feed water into the same system, some form of connection by the delivery pipes of both systems is inevitable. Cross-connections should be avoided, however, as much as possible as the failure of any portion of a cross-connection may put both systems out of business.

MOTOR DRIVEN CENTRIFUGAL PUMPS

The cost of power to drive a centrifugal pump in full service throughout its life is so large compared with its first cost that an inefficient pump is undesirable in any circumstance. Specifications now usually provide for severe penalties against low efficiencies.

In larger units with moderate lifts guaranteed overall efficiencies

of pump and motor of 83 percent may now be secured and maintained over a considerable range of delivery rates. Owing to internal water disturbances the centrifugal pump does not work well with high suction lifts. Seventeen feet is the maximum allowable and for best practice not more than 10 feet should be permitted. The design of the suction pipes should be such as to reduce friction and eddies to a minimum and to this end it is not now usual to provide foot valves, the non-return requirements being secured either by check valves or automatic stop and check valves placed on the delivery side of pumps.

The type of pump developed for waterworks purposes has a single closed impeller balanced both statically and dynamically and is provided with volute casing and blades. The pump has a double suction inlet, horizontally split casing, oil ring bearings and double labyrinth packing. The glands where the pump shaft passes through the casing are water sealed.

Such a pump gives its highest efficiency at not too high lifts. Where lifts of 200 feet or more are required it is usual to provide two similar pumps in series. The experience with multiple impeller pumps to the same end has not been so satisfactory.

The diameter and shape of the outlet nozzle of a centrifugal pump is such that the water leaves the pump disturbed and at high velocities, and it is desirable to recover a high proportion of the velocity head by Roman mouthpieces before introducing bends where a considerable loss of energy would otherwise take place. The ordinary check valve placed close up on the delivery side of a pump also absorbs a considerable amount of energy and it is now regarded as proper to introduce stream line stop and check valves, such as the Johnson Lardner or the Cone, in which the loss of energy may be made very small. These valves are also superior to the check valves because they can be set to shut off automatically the return of the water through the pump on power failure in such a way as to ease off the inevitable shock which even large air vessels, probably desirable in any case, do not entirely prevent. Special gate valves, if placed on the delivery pipes, may in some cases also be adapted to the purposes of stop and check, although not as satisfactorily as with the stream line valves. All delivery pipes from pumps should be provided with meters and both suction and delivery pipes with pressure gauges, so that the efficiency of the pumps may be obtained at any time. The meters also serve for the automatic supply of treat-

ment chemicals such as alum, lime or chlorine. The stream line stop and check valves previously referred to have been conveniently placed within the expanding tube of Venturi meters without any loss in energy. Where the pumps operate under a positive suction, pressure stop valves placed on the suction pipes must be provided in order to secure access to the pumps for repairs.

Where the pumps operate on negative suction head the suction pipes are best placed straight down vertically into open suction wells. It is good practice to provide duplicate suction wells with the pumping equipment divided between them.

The delivery pipes are often placed in depressed channels below the pumping station floor or in basements. Either of these arrangements have the disadvantage that bends in undesirable situations are necessary. This difficulty may be mitigated to a certain extent by the use of vertical delivery nozzles. The best and most economical arrangement with large size pumps, however, is to sink the pumps into deep pits which shorten the suction pipes and the delivery pipes deliver the water direct to the manifolds.

In selecting the size of pump to be adopted in a given case, generally some diversity of size is required to meet variable demands so that the power bill may be a minimum. A good arrangement of sizes is of the order 3, 2 and 1 from which a selection can be made so that the pumps in service may be operating near their full capacities. The failure of any one unit at any time must result in a replacement with standby equipment. The total pumping equipment needed depends upon the available service reservoir capacity and the maximum demands.

Provision has to be made for charging pumps when operating under a suction lift. This can be done by steam or water ejectors, but rotary air pumps electrically driven have also given satisfactory service in this connection. When starting up a pump the stop valve on the delivery pipes should be closed until full speed has been secured, when the stop valve may be opened. This is done automatically by the stop and check valves previously referred to.

Coarse racks and revolving screens now usually form part of the equipment of a pumping station. These prevent damage to pump or difficulties in the purification works, particularly in removing frazil or floating ice.

ELECTRICAL EQUIPMENT

The electrical portion of a pumping station equipment, always of considerable importance, has become with the experience of years more substantially safe and reliable, but it may cost considerably more than the pumps and motors.

The motor and pump are placed on the same bed plate and are directly connected through a flexible shaft coupling. With small pumps squirrel cage induction motors are used, but in the intermediate sizes induction motors with wound rotors are used and in the large sizes synchronous motors are to be preferred. Synchronous motors have a unity power factor and are the most economical to run. Induction motors with wound rotors are desirable in situations where variable pressures or quantities are required, but there is considerable loss of energy in running such motors at reduced speeds.

The voltages adopted depend to some extent upon the electric supply service conditions, but, in general, it is found desirable to bring the power through one or more independent lines from the nearest substation at the moderately high pressures of 11,000–13,000 volts and transform down to the voltages required at the pumps. In most stations of any size three operating voltages are required, for lighting and general service requirements, 220–100 volts; for motors up to 100 H.P., 550 volts, and for larger motors, up to and over 4400 volts. When starting up motors at full voltage, which is always done with small motors, the inrush current may reach six times the running current. With the larger motors this will cause considerable disturbance to the outside power circuits and auto transformers are provided with one or more steps which supply power to the motor at reduced voltages for very short intervals on starting until running speed has been approached. Such equipment adds considerably to the switching gear, because oil breakers automatically operated are required for each step and in the line starting has been applied to larger and larger motors and now 500 H.P. motor driven pumps may be safely started in this way. Synchronous motors in some instances are provided with multiple windings, which, within limits, produce the same effect as auto-transformers in reducing the inrush currents on starting.

The switch gear for starting, controlling and protecting the motors will naturally depend upon the size of the motor and the voltages of the current to be applied. Knife edge switches breaking in air can only be used with the smaller motors. With the larger motors oil

immersed breakers are invariably adopted. These are seldom operated directly and some form of remote control is adopted, either by levers or push buttons, using some relay system with either alternate current solenoids or D. C. from batteries. Such switch gear is so installed as to cut out with both overload and low voltage and its rupturing capacity must be so high as to cut out the maximum short circuit that can possibly pass through it. Thus the size of a switch or breaker as it is usually called will depend more upon the power behind it rather than the work to be done in front of it.

Instruments operated by low voltage currents for measuring the voltage current reactance and power absorbed are usually provided for each pump. These are mounted at or near the switch operating mechanism. The use of metal cubicles or metal clad switching equipment filled or not, although expensive are likely to be adopted for the more important stations in the immediate future owing to shop assembly of the units and their inherent safety. The switch gear can conveniently be placed in separate units along the pumping station wall conveniently close to the motor or they may be grouped into one board covering the requirements of the whole pumping station, including lighting and service, conveniently placed overlooking the whole of the important electrical equipment.

All high voltage equipment has to be out of reach and either effectively covered or protected with grounded metal fencing. It is necessary to provide disconnecting switches in order to be able to isolate the oil breakers. The disconnecting switches have heretofore been operated with a long stick, but only after the oil breakers are opened. Large oil breakers are now installed which automatically open the disconnects immediately after the breaker is opened. The cables conveying the power from the switches to the motors are usually drawn through fibre ducts which are buried under the floor of the pumping station laid as straight as possible. Where bends in the ducts are necessary they should be wide and sweeping.

On the occasion of a power failure some form of auxiliary lighting is required. Batteries have been used for this purpose, but often the stored water of the system is used to drive a small generator supplying current to independently wired lighting circuits. These machines are now made to cut in automatically as soon as the voltage drops below a given figure in the main electrical system.

The transformers supplying current to the switch gears are placed either out in the open or in separate buildings as the danger of oil in

which the transformers are immersed being scattered around is a real one in the case of a short circuit.

The transformers like the motors must be provided with oil breakers, disconnects and lightning arresters and protected from casual contacts. The oil breakers between the transformers and the line or lines must also have a rupturing capacity sufficient to break with certainty the full power of the line behind it with a dead short circuit in front of it.

PUMPING STATION

The pumping station itself should be fireproof and have ample room for access to the various units and proper provision should be made for future extensions. It is usual to traverse the whole area of the station with a travelling crane capable of lifting the heaviest piece of machinery. The floors are usually covered either with tiles or terrazzo, although sometimes concrete treated with a hardener is adopted. Ordinary concrete is too dusty. The walls up to hand reach are faced with glazed brick. Operating tables on which four-way cocks are mounted for controlling the hydraulic parts of the station are sometimes adopted. Provision has to be made for heating plant, offices, lavatories, showers and men's quarters. First-class quarters for the men and an orderly, neat and clean appearance of the pumping station engender a good spirit on the part of the operators. The building itself should be a work of art as well as for service, and the skill of an architect is always desirable in arriving at a satisfactory layout. The approach road and grounds should be laid out with taste and preferably kept clear of or distant from other municipal domestic or industrial undertakings.

Because of the fire hazard, gasoline standby engines for driving pumps are often placed in separate buildings, but this is sometimes difficult or inconvenient to do. In any case, the Fire Underwriters restrict the storage of gasoline within the building to a small amount and proper ventilation will make the pumping station safe. The cost of running pumps by gasoline engines is usually several times as great as with electric motors, so that such engines are only used in cases of emergency and seldom to reduce the peak load. On the other hand, diesel or other form of oil engines or steam engines, owing to their cheaper fuel, are quite suitable for both the emergency and the reduction of the electric power peak load. For either type of internal combustion engines adequate foundations, much heavier

than for electric motors, are required. Cooling water and exhaust pipes must be provided. The former introduce no difficulties, but the latter, with silencers and chimneys, have to be provided for in the architectural layout in such a way as not to obstruct the travelling crane or the fairways.

It is not proposed to deal in any way with steam standby pumps, because, except in the larger cities, few new steam pumps are being provided. Low pressure steam is, however, used for heating purposes. Various kinds of low pressure boilers are used for this purpose, but the most usual in the larger stations are the simple H.R.T. boilers, set in brick work, operated at less than 10 pounds pressure. The heating system is provided with vacuum return pumps electrically operated and automatic boiler water feeders.

(Presented before the Canadian Section meeting, March 10, 1932.)

INTERCONNECTION OF ELECTRIC CIRCUITS WITH WATER PIPING SYSTEMS

By J. B. Downer

(*Water Department, Seattle, Washington*)

This paper has not been prepared with the idea of adding to the sum total of knowledge on the subject. The intent has been to bring out a few points of interest to the average water works man who has not the time to search libraries. Technical electrolysis men will find nothing new here. Exactitude has possibly been sacrificed to some extent in attempting to give a general idea of the subject. Some technical terms are unavoidable, because after all, it is a technical subject. The terms used will be familiar to most of you. However, as the subject is rather interesting I want everyone here to understand what we are saying. If the engineers and water works men will excuse me for a few moments, I will try to define some of the terms for the benefit of any others who may not be conversant with them.

In the electrical industry, a *conductor* is any thing which will permit electricity to flow through it. For the purpose of this discussion, it will usually be a copper wire.

Potential is to electric power, what *head* or *pressure* is to hydraulics.

Potential drop or *voltage drop* corresponds to *loss of head.*

Line loss corresponds to *friction head.*

An *insulating joint* is inserted in a pipe to interrupt its electrical continuity without interfering with the flow of liquid through the pipe.

An electric current on a pipe does no harm. It does no harm in entering an iron pipe, but if direct current flows *from* a pipe to moist soil, the pipe will be corroded. If current can be taken from a pipe on a metallic conductor, no harm is done to the pipe.

Pipe drainage is the term used to indicate removal of current from a pipe by means of a metal conductor.

A *meter shunt* is an electrical conductor forming a by-pass around a meter. Its purpose is to preserve the electrical continuity of the pipe when the meter is removed. It operates to prevent a difference of potential across the meter gap in case current is flowing in the pipe.

The first electric circuits carried direct current. One conductor was positive, the other negative. Edison, true to form, devised the three wire circuit having one positive conductor, one negative and one neutral, making the three wires serve in place of four. The neutral wire was positive when the heavier load was on one outside wire and negative when the heavier load was on the other outside wire. When the load was equal on both outside wires, there was no current in the neutral.

When alternating current apparatus was developed, the three wire circuit was continued in use. The conductors lost their positive and negative significance but the "middle" wire is still called the neutral. The voltage between either "outside" wire and the neutral is half of the voltage between the two outside wires. If the neutral is grounded, theoretically, the greatest voltage between either outside wire and the earth will be half of the normal voltage between the outside wires. The a.c. neutral serves as a "return" for either outside wire just as in the former d.c. circuit. The above is true of the ordinary three wire, single phase circuit used for light and power. There are other three wire circuits which we need not consider here.

It was the development of alternating current machinery which made possible the long distance transmission of electric power. When an electric current flows through a conductor, there is always some power lost. This loss, sometimes called the line loss, is proportional to the square of the current. The line loss in transmitting a given power at one volt potential will be one million times as great as if the same power is transmitted at one thousand volts potential. The voltage of alternating current can be readily "stepped up" or "stepped down" by transformers, so that enormous power can be transmitted at high potential and with very small line loss. Direct current, on the other hand, must be transmitted and used at the voltage at which it is generated. Consequently, the conductors must be very large and relatively short or the line loss will be greater than the load.

There are a few purposes for which alternating current cannot be satisfactorily used. For instance, there is no economically practicable a.c. motor having the variable speed and the large starting torque of the d.c. series motor. These characteristics make the d.c. series motor most suitable for street car service and for some other power applications. The so called "universal" motors used on small vacuum cleaners and the like are series motors and will operate on

either a.c. or d.c. They are not suitable for a.c. operation in the larger sizes, such as would be required on street railways.

GROUNDS

The interconnection of electric circuits with piping systems has been practiced since the beginning of the electric industry. It is the electrician's favorite method of "grounding." Preference has always been given to the water pipe rather than the gas pipe because of the explosive nature of gas. As a matter of actual fact, a ground on either of these piping systems amounts to a ground on both so far as any ill effects are concerned.

We will speak particularly of the water pipe because that is the pipe in which we are most interested. Anything we say of that pipe will apply to any other continuous piping system. The earth is so crowded with vagrant electric currents of one origin or another, that ordinary prudence compels the gas worker in most cities to treat any pipe upon which he works as though he knew it was carrying current. The grounding or non-grounding of electric circuits on the pipe need not affect his conduct in this respect.

The term "ground" is used in the electrical industry to express a number of related ideas. An electrical man once asked me "Do you think I will get a ground, if I dig down in the ground there about ten feet and put in a charcoal ground?" We will use the word as meaning any means of securing electrical contact with the earth.

Let us first discuss briefly, the characteristics and purposes of grounds and then examine the possible and probable effects of using the water pipe as a ground.

A good ground must have very low resistance, so that it may carry a heavy current without causing a large voltage drop, or in other words without permitting a dangerous difference of potential between the grounded conductor and the earth. It must also have sufficient surface in contact with the earth, so that it may discharge this heavy current for a considerable time without drying the soil. The drying of the soil would increase the resistance to earth, thus raising the potential drop across the ground and defeating its purpose.

Satisfactory grounds can usually be secured by means of buried plates or driven pipes or rods. But to secure adequate carrying capacity and sufficiently low resistance requires an enormous number of these rods sprinkled over a large area and connected together. Their resistance and carrying capacity varies with the weather and

they require continuous testing and constant maintenance if they are to remain effective. Electricians refer to them as "artificial" grounds, using the word in the same sense in which it is used in speaking of "artificial flowers." Inspectors distrust them. To them, there is one, adequate, natural God-given, ground—the water piping system.

We will find it convenient to classify grounds as to use as Utility grounds and Protective grounds. Protective grounds may be subdivided into Circuit, Equipment, and Lightning Arrester grounds.

Grounds were first installed in order to utilize the earth as a part of the electric circuit. This type of grounds we will call Utility grounds. The first commercial electric industry was the telegraph system. They found it convenient and economical to use the earth for one side of their circuits. They still use it. The early telephone system adopted the same plan. Some of the rural lines still follow it. The modern telephone, however, uses an all metal circuit for their talking circuit. Many lines still use the earth in their ringing circuit. This circuit employs alternating current. Burglar and fire alarm systems frequently use the earth as one conductor. Power and light systems have occasionally used the earth as one conductor, but not extensively. A small number of utility grounds are used surreptiously, by electricity consumers for the purpose of by-passing their electric meters or for the purpose of utilizing low voltage equipment on power supply of higher voltage.

It has not been found practical to insulate some electric circuits permanently and effectively from the earth. There is always some leakage and despite the utmost vigilance accidental grounds will occur through faults in insulation, mechanical stresses, tampering and the like. These accidental grounds create a hazard to life and property.

Professor Thompson discovered that by properly grounding electric circuits, the hazard from these accidental grounds might be materially reduced. Grounds installed for this purpose are called protective grounds. Protective grounding is not one hundred per cent effective. At best it substitutes one hazard for another. Electrical men debated its merits for years, but its use has grown until it is nearly universal. Experience has shown that when electrical systems are constructed with the idea of grounding in mind, and when effective grounds are secured, the greatest measure of protection is gained for the electrical consumer as regards both the personal and the property risks.

Protective grounds are the grounds referred to in the National Electrical Code and the National Electrical Safety Code.

The function of the protective circuit ground is to maintain one point of an electric circuit at practically the same potential as the earth. It is not *intended* that the earth shall normally serve in place of a metallic conductor of the circuit, but that the ground shall act as a relief valve to prevent a difference of potential between the grounded wire and the earth, thus limiting the potential difference between earth and the other conductors of the circuit to a predetermined value, even though a higher voltage may be accidentally impressed upon the circuit. The degree of protection obtained depends upon the resistance in the ground and its carrying capacity. A poor ground offers slight protection and it is debatable whether a poor ground is not an added hazard in some cases. It may be said, in general, that the more grounds on a circuit the greater is the degree of protection. Each added ground reduces the total resistance to earth and increases the magnitude of the current which may be discharged with a given potential drop. Further, a multiplicity of grounds assures that all parts of a conductor will have satisfactory protection even though the conductor may be broken.

Equipment grounds serve to connect metal frames of machines, conduits, etc. with the earth. Their function is to prevent a dangerous difference of potential between the earth and the grounded metal frames, etc., in case of a failure of the insulation between the frames and the live parts of the appliance or machine. In case of such failure, equipment grounds function the same as circuit grounds until the circuit breaker opens or the defect is remedied. Normally these grounds carry no current.

The function of Lightning arrester grounds is to conduct atmospheric electricity harmlessly to earth to prevent its seeking a destructive path of its own.

Grounding on water piping systems

The maximum protection of the user of electricity is undoubtedly secured by a large number of grounds. The most effective and reliable grounds are undoubtedly secured by utilizing an electrically continuous underground piping system for the earth contact. A water piping system frequently is electrically continuous—occasionally it is not.

The National Electrical Code formerly carried a statement that

protective grounding on water piping systems offers the best protection to life and property and is harmless to the piping system. The statement has been omitted from recent editions of the code.

A Bureau of Standards Publication (Tech. Paper #108, p. 208, par 29) states—"Because of the great advantage to the public, and the slight disadvantage, if any to the public service corporations resulting from grounding to water pipe such grounding should be made compulsory in cases where it is necessary to protect human life. There is moreover a joint responsibility between the several public service companies concerned, because both contribute to the life hazard by running their pipes and circuits near each other in buildings."

There are three interests involved in connecting electric circuits to water pipes, viz.—the public, the electric industry and the waterworks. Two of these interests—the one producing the hazard and the one for whom protection is sought, are represented on the N. E. Code Committee. The other interest, whose property it is desired to use is not represented. It is time the A. W. W. A. had representation on that committee.

There are two possible hazards to waterworks interests in the promiscuous grounding of electric circuits on water pipes—a life hazard to waterworks employees and a hazard to the pipes from electrolysis.

We will first take up the code requirements and see if they adequately protect us from these hazards.

The code prohibits the use of the street railway current in any building which is not a part of the railway system (sec. 204). This provision removes a possible personal hazard and a probable source of electrolysis.

The code prohibits the use of more than one ground on a direct current circuit. (902a and 903a) This prevents another source of electrolysis because if more than one ground is allowed, current in the grounded wire would divide, part flowing in the wire and part flowing through the earth. That part of the current flowing through the earth would be an electrolysis hazard to underground structures whether the circuit was grounded on the water pipe or otherwise. There is no need for more than one ground on a direct current circuit because the line loss requires that the d.c. conductor be so large that the danger of a break is very slight. The resistance of the wire is so low that there is little likelihood of a dangerous rise of potential to

earth from an accidental cross with a circuit of higher potential, if the station ground is effective.

The code provides that there shall be no "Objectionable" current in the ground wire. It further requires that "where an objectionable current occurs due to multiple grounds, (1) one or more of such ground shall be abandoned, or (2) their location shall be changed, or (3) the continuity of the conductor connecting the grounding connections shall be suitably interrupted, or (4) other means shall be taken to limit the current."

These provisions for limiting the current in the ground wires are required for the protection of the interior wiring systems and may serve that purpose. I do not know whether the committee had the protection of piping systems in mind when they wrote that section. Later we will consider it from that angle. The code does not say how it is to be determined that a current is objectionable or who is to be the judge. Presumably the question is to be left to the discretion of the inspector. He is not responsible to the water works manager. I suppose the vague term is used because the committee did not have a definite term to fit the case. I wish I could suggest one to them. I cannot, but I can suggest to you a way to avoid any dispute about the matter. If you permit the use of the water pipe as a ground, reserve the right to remove any wire at your discretion and at the expense of the party who installed it. Then let it be distinctly understood that any ground wire will be removed if it is found to carry any direct current[1] (unless the pipe is drained).

I believe you need fear no trouble from the alternating current. The only damage it can do is to heat the pipe and it will become "objectionable" to other interests before it will harm you in that way.

When the water meter is located inside the building, the code requires that the ground connection shall be located on the street side of the water meter, or the meter shall be shunted. (Sec. 908d) This provision is intended to assure the permanent continuity of the ground connection. It serves to protect a man from shock in case the meter is removed, while the ground is functioning.

The committee appears to assume that if the water meter is in the parking strip the service pipe between the meter and the house will afford an effective ground. This may be true in some parts of the country. It is not true in Seattle.

[1] It is here assumed that the circuit is constructed in accordance with the current N. E. Code.

This brings out the point that the proper grounding scheme for a particular locality is a local problem. I do not believe that any program can be worked out which will be equally satisfactory, for instance, in Seattle, Wenatchee and Chicago. The effort to standardize electrical construction is commendable. But standard grounding rules applied to diverse climatic and soil conditions, or to waterworks and electrical systems constructed upon different schemes, will not produce standard results.

I have found as high as 90 volts across the water meter gap when a 115 volt circuit was grounded on the water service pipe. The meter was at least 50 feet from the house and the intervening land was used for a garden. In this instance the consumer was using the water pipe in place of the neutral wire to defraud the electric company, but it reproduces the condition you would have with the electric circuit grounded on the water pipe and the service neutral broken.

The code requires that the neutral of every alternating current service shall be grounded on the premises. If these grounds are made on the water pipe, the neutral main could be broken or entirely removed and the electric system would function as well as though it were in place and intact. The electric company would have no way of learning that the neutral was broken except by accidental discovery.

It must be admitted that this scheme affords maximum protection to the electric consumer, if the service is grounded upon water pipe. It must be also admitted that the degree of protection is very little greater than that afforded by adequate grounds on the neutral main if the neutral is of proper size. If the service be grounded by so-called "artificial" grounds, the protection is probably less than if the service be ungrounded and the neutral main grounded upon the piping system. The scheme, whatever its intent, has the effect of transferring the responsibility for the ground from the utility to the consumer. If the neutral main is maintained the scheme would eliminate the shocks now occasionally inflicted upon men working upon water pipes on which defective electric appliances are grounded.

The tendency would be for electric companies to use smaller and smaller neutrals since the neutral would not be necessary as a conductor, once all their services were grounded on the water pipe.

In localities having climatic conditions and service installations similar to ours, shunts should be installed around water meters by the water department and paid for by the party making the ground connection, if circuits are grounded on the water pipe at the premises,

or guarantees should be secured that the neutral main will be maintained of proper size to assure its continuity under all conditions. Full protection to waterworks employees requires that the grounds shall be so located, of such number, and connected by a neutral of such size that under no circumstances will any pipe become the only path to earth for current from any circuit.

Equipment grounds, during the time they are fulfilling their mission of protecting the equipment, carry all the hazard of circuit grounds. The difference is that they are seldom active and usually for short periods.

Utility grounds should be discouraged, if they are on circuits subject to dangerous potential or carry direct current of considerable magnitude. Little or no damage has been caused by the telegraph grounds. If a man should attempt to remove a meter or disconnect a service, which serves as the only ground for a long distance telegraph line, he would be subject to a serious shock. When these lines are grounded on water pipes, they should be connected to two or more separate services or to an additional adequate ground aside from the water pipe. If your telephone is a "party line" the water pipe is probably included in the ringing circuit. In that case, a man removing the water meter, while the bell is ringing, would receive a thrill, to say the least. His life would not be endangered, however, because the circuit is only closed while the bell is ringing, not long enough to do more than insult him.

Lightning arrester ground wires are required by the code to be separate from all other ground wires. In our territory, lightning arresters operate very infrequently. I do not feel competent, at this time, to discuss these grounds beyond pointing out that, if they are connected to rod grounds, it is possible to create so great a potential gradient in the earth near the "ground," that a person might be killed without coming into actual contact with the conductor.

It would be easy to overestimate the hazard to life from electric circuits. However, I have always felt that it is not the business of the waterworks operator to measure the magnitude of the hazard. If the hazard is sufficient to require protective measures for the benefit of the electrical consumer, it is too large to be transferred to the water works employee. Both consumer and employee can be protected and should be protected and that at the expense of the utility producing the hazard.

ELECTROLYSIS HAZARD

Now to consider the electrolysis hazard. If you are operating in a territory where there are no electric railways, this feature will not concern you. If there is an electric railway in your territory, there is a difference of potential between various points in the earth due to current leaking from the rails. If the neutral wire of the electric distribution system is grounded on the water pipe at two points between which there is a difference of potential, the stray railway current will flow over the wire to the point of low potential on the pipe. This current will be added to the current already discharged by the pipe and every ampere so delivered will mean a probable annual loss of from fifteen to twenty pounds of iron, *added to your present loss.*

You will agree that a very small direct current in the ground wire will be "objectionable" to you. Some years ago, I suggested that this difficulty might be met by draining the a.c. neutrals to the railway negative feeder, thus protecting the water pipe from the railway current while permitting it to serve as a ground for the a.c. circuit. The matter was referred to the, then, electrical field secretary of the National Fire Protection Association. He strenuously objected, on the ground that such a scheme utilized the electric distribution system as an electrolysis mitigation instrument. He appeared to see a difference (not apparent to me) between the ethics and desirability of using a water pipe to protect an electric circuit and the ethics and desirability of using an electric circuit to protect a water pipe.

Many water piping systems contain a number of insulating joints. If a wire is grounded on the pipe on each side of the insulating joint, the effectiveness of the joint will be destroyed. It all simmers down to this. If electric circuits are grounded on the piping system, you will probably have to adopt pipe drainage as a mitigative measure, rather than insulating joints. The code provisions for limiting current in the ground wire are probably effective so far as protecting the interior wiring systems is concerned. Let us try them as a means of preventing the transfer of this stray direct current. If we attempt to solve the problem by "abandoning one or more of such grounds," we will find that the grounds remaining are either all in the rail-positive area or all in the rail-negative area. "Changing their location" will bring us to the same condition. "Interrupting the continuity of the conductor connecting the grounding connections" will be found ineffective, in many cases, unless insulating

joints are cut into all underground structures at the same point. I am anxious to hear of "other means" which will be effective in adequately "limiting the (stray railway) current." I anticipate that these other means will have to be applied to the railway circuit.

If a premises is wired for alternating current and grounded, either on the waterpipe or otherwise, and the service is later changed to direct current, the ground should be removed. Failure to remove it will certainly cause trouble. Your best chance to secure its removal will be by securing the co-operation of the power company either to check the wiring before connecting direct current services or to notify you.

Up to this point, it looks like the waterworks operator would be justified in refusing to have anything to do with the grounding of electric circuits.

There are some reasons why he cannot afford to take this attitude. In the first place, if a person is killed in your territory, it is one of your customers. If a house is burned, the loss is suffered by one of your customers. You would personally go to considerable trouble and some expense to prevent either of these misfortunes, if you could know about it in advance. You would not want to have to say to yourself, "I could have saved that life." Or "I might have prevented that fire."

Then, you have not the choice of whether you will have grounds on your pipe or will keep them free of grounds. Your choice is whether you will have adequate and proper grounds, installed under your supervision so as to protect your employees and your property, or whether you will have only accidental and mischievous grounds, which you can not prevent on your pipe.

Public interest requires that secondary alternating current circuits shall be grounded. If they are grounded on the steel frames of buildings or on the reinforcing steel of concrete buildings, they are on your pipe because the pipe is in contact with the steel on the premises. If they are grounded on the gas pipe, there are innumerable contacts between the gas and water pipes. We frequently lose a service from electrolysis where we find the current coming from the house. It entered on the gas pipe. If equipment is grounded on the a.c. neutral, every electric water heater is a potential contact between neutral and water pipe. Many of them are practically direct contacts.

Let me cite two concrete cases.

A short time ago, there were installed in a certain house, an electric refrigerator, an oil burner (hot water furnace) and an electric hot water heater. The wires supplying these appliances were run from the distribution box to the equipment in three separate flexible metal conduits. The electric service was run underground from across the street, in 1¼-inch galvanized pipe conduit. This galvanized conduit extended over one hundred feet in the earth. Neither conduit nor conductor was grounded on the water pipe. A contact occurred on the pole between the conduit and one of the hot conductors of the service. The current flowed through the service conduit and the flexible metal conduit to the water service pipe, via the furnace, water tank, and cooling coils. The current was heavy enough to heat the flexible metal conduits and start a fire. The water department would have been "no worse off" if the conduit had been grounded on the water pipe. The current flow would not have lasted so long and there would have been no fire. I might add that the omission of the ground was due to an error of judgment on the part of the wireman. He assumed that the long run of conduit in the earth would serve as an effective ground.

In June, 1931, we installed a 1-inch service to supply property adjoining a railway substation. There was no railway on the street, the negative feeder extending several hundred feet to contact with the rails. There was a driven rod grounding a lightning arrester about twelve or fifteen feet from the service pipe. The service failed in October and again in March. We found that railway current was leaking from the service pipe and being picked up by this rod ground. An accidental contact inside the substation was delivering the current to the railway negative. Had the lightning arrester been grounded on the water service, we would not have lost the service.

As suggested above, it is difficult, if not impossible, to judge effects of grounding in one locality by the effects produced in another locality. The most satisfactory method of handling the problem is by forming a local committee of representatives of the various interests involved. Let such a committee study the local problem as it affects each interest concerned, determine what ought to be done, and how it can be accomplished. Your representative on such a committee can see to it that your interest is protected. There is a satisfactory solution for this problem in every town, but it does not follow that the solution will be the *same* in every town. When the technical problems have been solved, the rest is a matter of negotia-

tion between the several interested parties. This negotiation should be kept separate from the technical investigation. If the technical men are responsible for matters of policy, there will be more of "squabbling" and of "fencing" than of investigating. If you are (or expect to be) engaged in litigation over your electrolysis loss, you will want protection against a possible claim that you have contributed to your loss by permitting the interconnection of your pipes with the electric circuits.

SUMMARY

The interest of the public is best served by effective grounding of a.c. secondary circuits. In most cases the water piping system furnishes the most reliable ground.

The promiscuous and unsupervised grounding of circuits on water pipes may transfer a life hazard to waterworks employees, and may increase the damage to the piping system from stray railway current.

Gas pipes and water pipes are in contact at so many points that electrolysis and other hazards are common to both if either is used as a ground.

The complete protection of waterworks employees requires that the grounds be so located, and connected by a neutral of such size that under no circumstances will any particular pipe serve as the sole path to earth for current from any circuit.

The water service pipe does not constitute a "ground" in some localities and if circuits are grounded on water service pipes, the meter should be shunted even if it is located in the parking strip, or the a.c. neutral should be so large as to guarantee its continuity between grounds under all conditions.

Grounds made exclusively on water mains or hydrant branches, offer a negligible hazard to employees if ordinary care is used in locating and installing them. Such grounding also affords satisfactory protection to the user of electricity, if the neutral is maintained of adequate size. This system also leaves the responsibility for the ground with the utility instead of the consumer.

Telephone grounds, in general, do not endanger pipes or workers.

Alternating current does not endanger the piping system, and in cities where there are no trolley systems, grounding of electric circuits according to the N. E. Code, would introduce no electrolysis hazard.

Closed circuit, direct current signal systems sometimes use "earth return" for their circuits and may damage underground structures.

Multiple grounds on direct current circuits are hazardous to underground structures, even where the so-called artificial grounds are used. They are unnecessary and are prohibited by the N. E. Code.

Current from street railway circuits should not be used for any purpose aside from the railway unless the negative conductor is carried to the railway negative feeder. The N. E. Code prohibits its use in buildings which are not a part of the railway system.

If electric circuits are grounded on both sides of an insulating joint the effectiveness of the joint will be destroyed. Pipe drainage will be the only effective means left for combating electrolysis. The writer believes that the a.c. neutrals might properly be used in many cases in the drainage scheme. The electrical field secretary of the N. P. P. A. did not concur in this belief.

The N. E. Code provisions for limiting the current in ground wires are not adequate to prevent the transfer of current leaking from the rails of trolley systems.

Due to the variety of conditions, construction methods, etc., the grounding problem can be solved most satisfactorily for a given locality by a competent local committee.

The water works operator has an interest in the grounding question, aside from the question of direct connections on his pipes, because grounds made on other structures, not under his control, may result in a dangerous current on the water pipe.

(Presented before the Pacific Northwest Section meeting, May 13, 1932.)

THE EFFECT OF SALINITY ON THE VALUE OF WATER FOR INDUSTRIAL PURPOSES

By Sheppard T. Powell

(Consulting Chemical Engineer, Baltimore, Md.)

The drought of 1930–1931, and the resulting shortage of water over large areas of this country is still vivid in the minds of many people. Human distress, in certain sections of the country was so great during this period that wide publicity was given to the conditions through the daily and technical press. It is natural, and rightly so, that the industrial aspects of such a calamity, should be secondary to that of human suffering. As a consequence of this situation, few data have been published concerning the influence of the drought conditions on the quality and availability of industrial water supplies. The depreciation in quality of supplies so affected was very marked, however, and the economic losses which occurred were enormous. Certain of these losses can be computed from existing records. Other more intangible losses which may not be so readily evaluated, are, nevertheless, highly important. It is our purpose today to confine our remarks wholly to definite and calculable losses sustained in certain industries, without consideration of controversial and speculative losses involving purely engineering judgment.

The depreciation in the quality of industrial waters during a drought varies in different localities and is not dependent on a single factor. The chemical composition of water for industrial uses, is frequently, of great importance. Radical changes in the concentration of dissolved mineral salts have a far reaching effect, not only on the specific industry, but upon the economic life of a community which is dependent upon the industry affected.

The potential value of an industrial water is affected greatly by the presence of hardness, organic matter, and chlorides. Reduced runoff from water sheds, occurring during drought periods increases the concentration of these constituents. The magnitude of these changes is dependent upon the geological formations of the water sheds, the proximity to tidal water and the domestic and trade waste contamination of the streams.

Figure 1

Chart showing how the Hardness of the Delaware River Water increases as the Flow decreases. Results reported from Samples taken at Riegelsville, Pa.

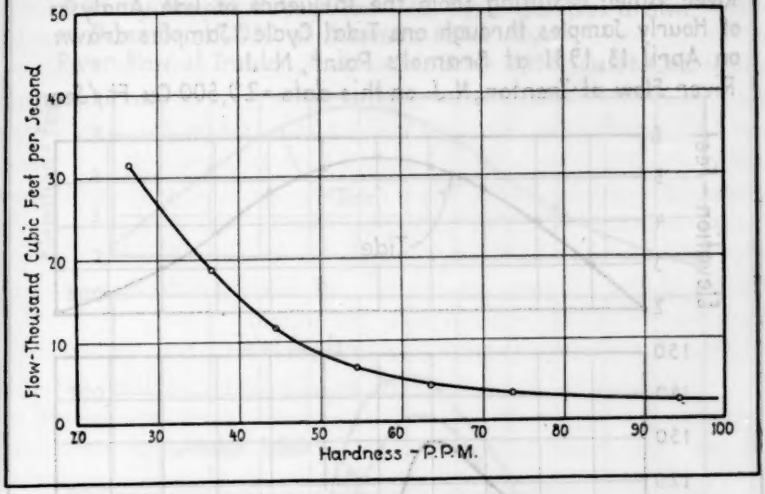


Figure 2

Chart showing how the Hardness of the Delaware River Water Increases as the Flow decreases. Results reported from Samples taken at Bramel's Point, N.J.

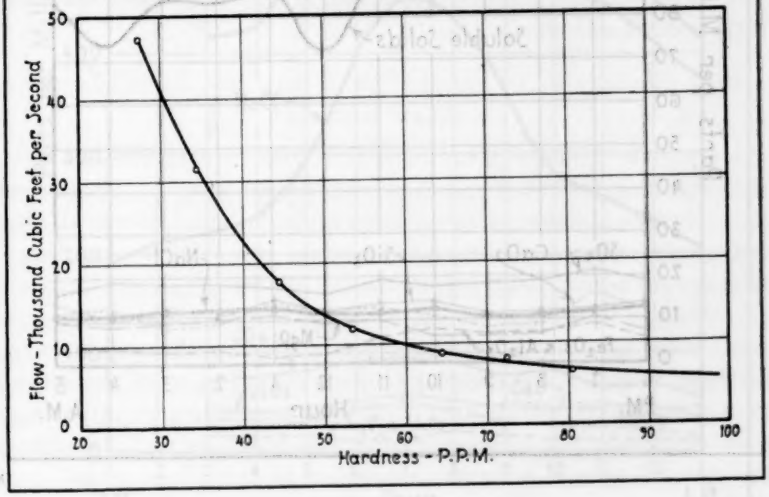


Figure 3
Fluctuation of the Chemical Composition of the Delaware River Water resulting from the influence of Tide. Analyses of Hourly Samples through one Tidal Cycle. Samples drawn on April 13, 1931 at Bramel's Point, N.J.
River Flow at Trenton, N.J. on this date = 29,500 Cu. Ft./Sec.

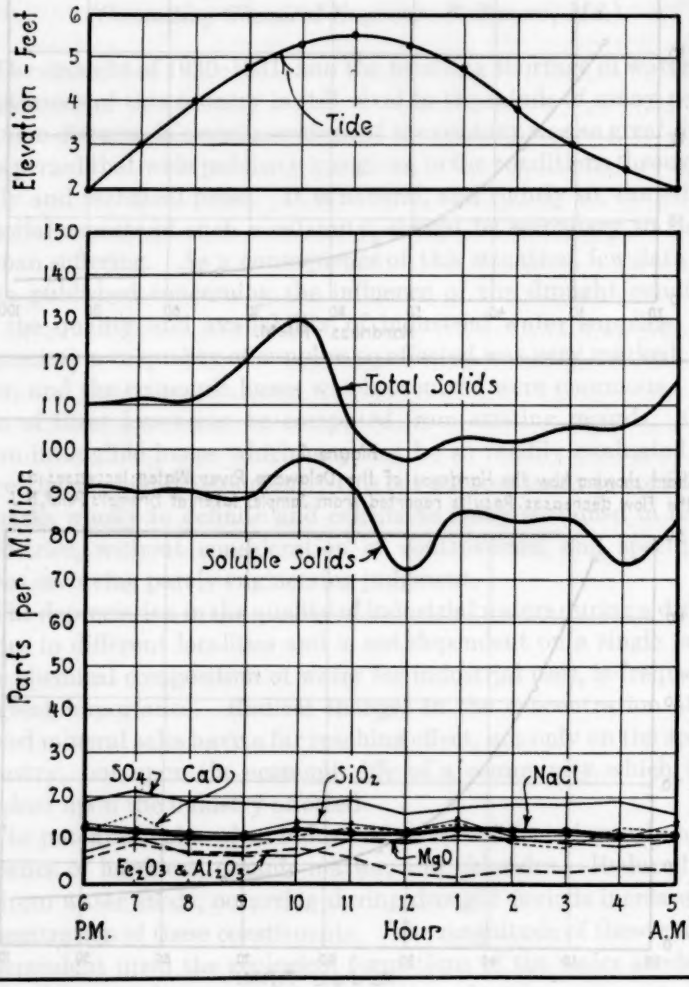
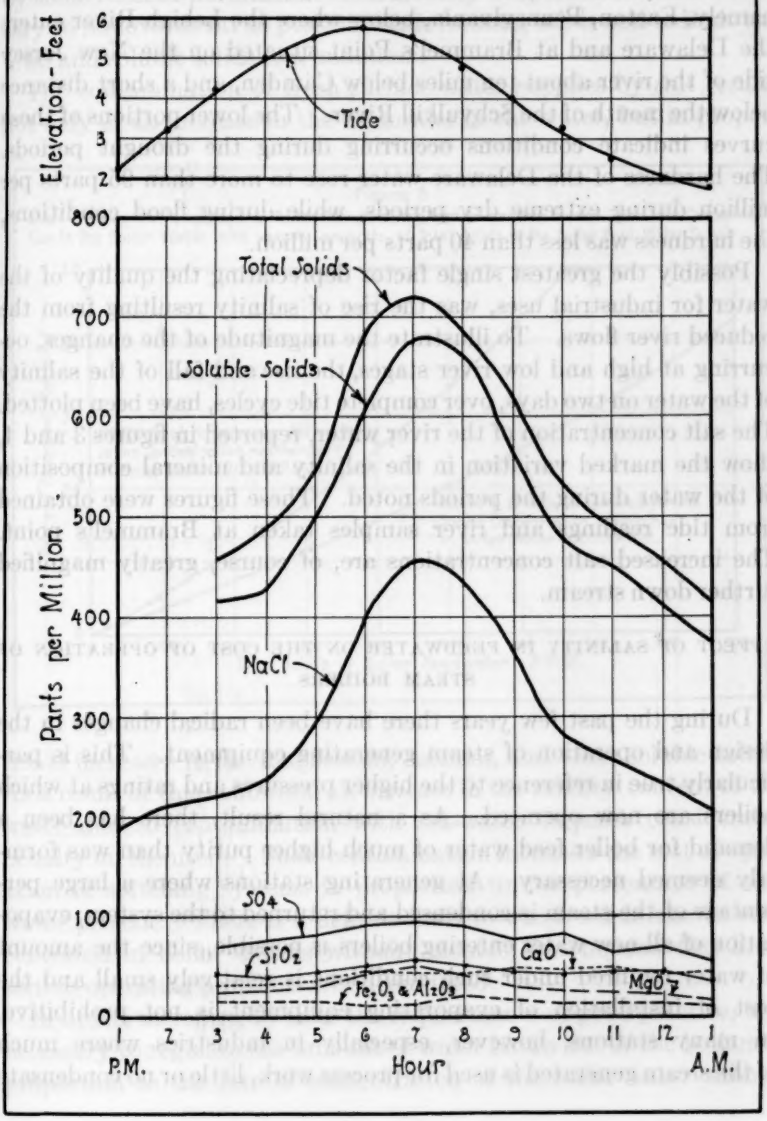


Figure 4

Fluctuation of the Chemical Composition of the Delaware River Water resulting from the influence of Tide. Analyses of Hourly Samples through one Tidal Cycle. Samples drawn on December 11, 1930 at Bramel's Point, N.J. River Flow at Trenton, N.J. on this date = 3,190 Cu. Ft./Sec.



The variation of the chemical composition of Delaware River water during the past few years, is characteristic of conditions elsewhere, where reduced river flows have occurred. The effect of run-off upon the mineral content of the river water is graphically illustrated in figures 1 and 2 which show the increased hardness of the river water as the flow was reduced. The figures reported are for two stations, namely, Easton, Pennsylvania, below where the Lehigh River enters the Delaware and at Brammel's Point situated on the New Jersey side of the river about ten miles below Camden, and a short distance below the mouth of the Schyulkill River. The lower portions of these curves indicate conditions occurring during the drought periods. The hardness of the Delaware water rose to more than 95 parts per million during extreme dry periods, while during flood conditions, the hardness was less than 40 parts per million.

Possibly the greatest single factor depreciating the quality of the water for industrial uses, was the rise of salinity resulting from the reduced river flows. To illustrate the magnitude of the changes, occurring at high and low river stages, the rise and fall of the salinity of the water on two days, over complete tide cycles, have been plotted. The salt concentration of the river water, reported in figures 3 and 4, show the marked variation in the salinity and mineral composition of the water during the periods noted. These figures were obtained from tide readings and river samples taken at Brammel's point. The increased salt concentrations are, of course, greatly magnified further down stream.

EFFECT OF SALINITY IN FEEDWATER ON THE COST OF OPERATION OF STEAM BOILERS

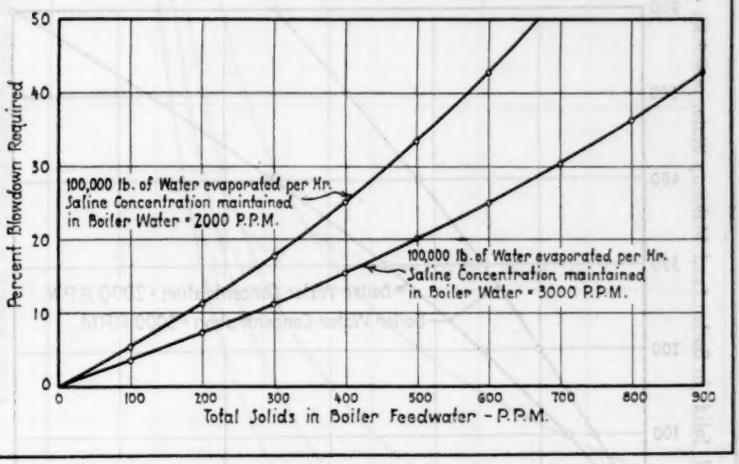
During the past few years there have been radical changes in the design and operation of steam generating equipment. This is particularly true in reference to the higher pressures and ratings at which boilers are now operated. As a natural result, there has been a demand for boiler feed water of much higher purity than was formerly deemed necessary. At generating stations where a large percentage of the steam is condensed and returned to the system, evaporation of all new water entering boilers is possible, since the amount of water required under such conditions is relatively small and the cost of installation of evaporating equipment is not prohibitive. In many stations, however, especially in industries where much of the steam generated is used for process work, little or no condensate

is returned to the boilers. The amount of water that must be treated under the latter conditions is relatively high, so that the use of evaporators may not be economically employed, owing to the relatively high investment and operating cost of this type of equipment. Satisfactory preparation of the feedwater must be accomplished, therefore, by some form of purification other than by evaporators. It is necessary to remove, as far as possible, scale forming solids and to limit the total and soluble solids to a minimum.

The contamination of fresh surface water supplies by salt results not only in an increase in the cholorides in the water, but in proportional increases in the magnesium, calcium, and other soluble solids. As a result of this condition, an increase in the salinity content of the water due to contamination with sea-water imposes considerable penalty on the users. Such contamination increases the cost of operation of softening systems in proportion to the percentage of sea-water present. There is a definite limit to which solids can be concentrated in boiler waters without trouble, but beyond this limit serious operating problems are encountered.

Figure 5

Chart showing the Percentage of Boiler Blowdown Required to maintain a given Total Solid Concentration in the Boiler Water with varying amounts of Total Solids in the Boiler Feed Water Supply



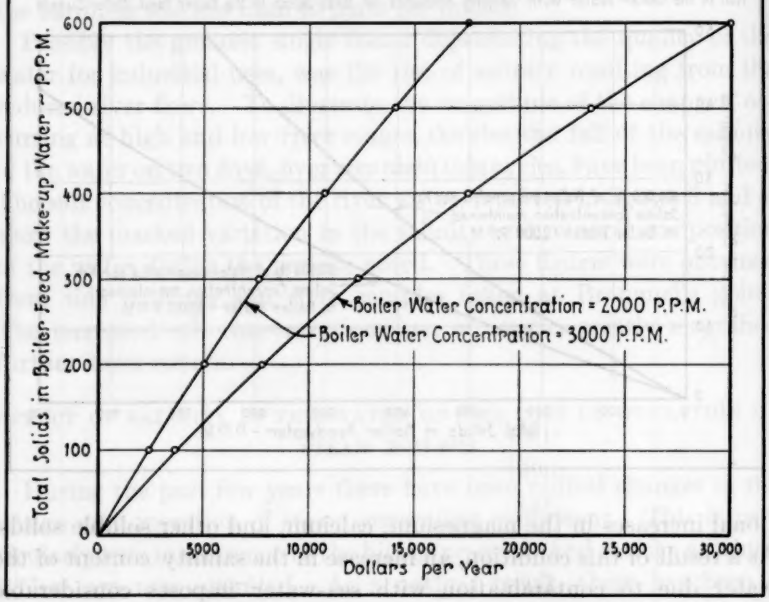
In order, therefore, to meet the requirements of good practice, it is necessary to regulate the amount of water blown out of the boilers in proportion to the rate of concentration of the boiler water salines.

The percentage of boiler blow down water required for safe operation, is greatly increased as the concentration of solids in the feedwater increases. This is graphically illustrated in figure 5.

The financial losses sustained, by the wasting of large volumes of hot boiler water may be excessive. Estimated losses which are possible under a specific set of conditions are shown in figure 6.

Figure 6

Chart showing Annual Loss, in Dollars, resulting from Blowing down Boiler without Heat Recovery to limit the Total Solids in the Boiler Water Saline to desired Concentrations. Figures reported for Heat Losses only and are based upon evaporating 100,000 lb. of Water per Hr, Fuel at $5.00 Ton, estimated Boiler Efficiency @ 75% and Boilers operating 75% of Year @ 100% Rating. Boilers operated at 400 lb. Pressure. (Figures do not include value of Water wasted)



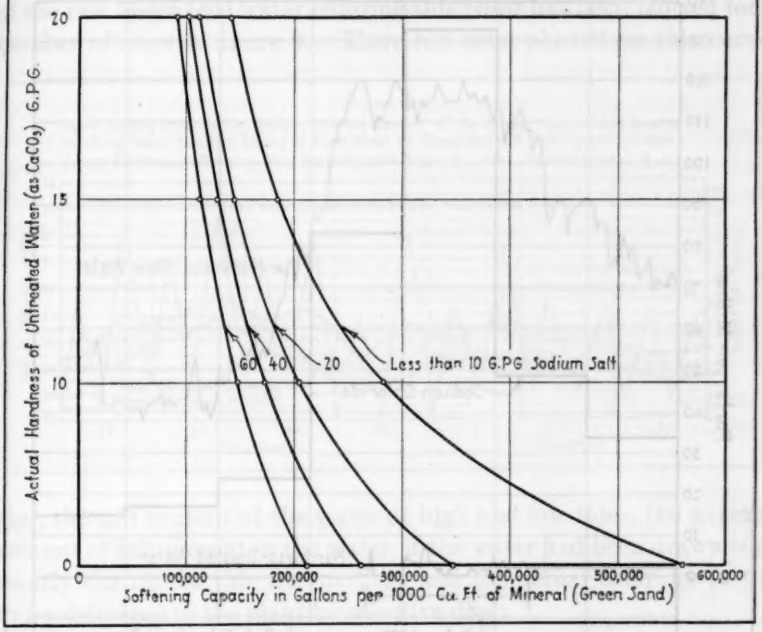
These losses, under some conditions, can be recovered by installing heat exchangers on the blow down lines and utilizing the heat from the blow down water to raise the temperature of the boiler feed. The economy to be effected by such recovery will de dependent upon the investment required for the installation of the necessary apparatus and upon the heat balance of the steam station. Even where heat recovery of the blow down water is possible, certain losses will still

persist, since complete heat recovery is not possible and there are appreciable losses due to the value of the water wasted.

INFLUENCE OF SALINITY ON THE OPERATION OF ZEOLITE SOFTENERS

Softening industrial water by zeolite mineral is practiced widely and under certain conditions is preferable to other forms of treatment. The efficiency of this form of treatment depends on a number of fac-

Figure 7
Chart showing the Reduced Performance of Softener Units due to Increased Sodium Chloride Content of the Raw Water



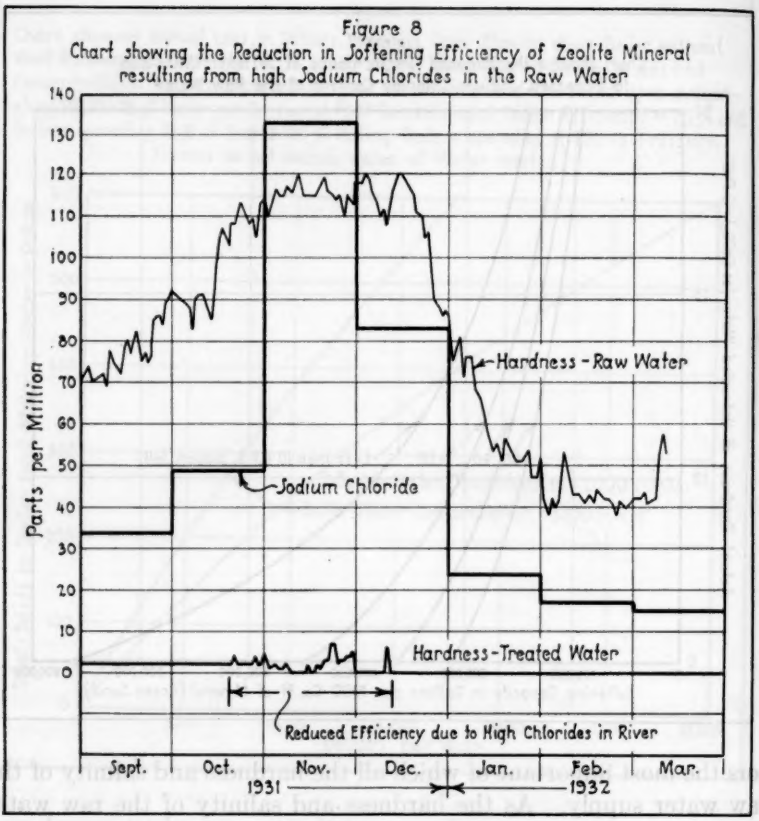
tors the most important of which all the hardness and salinity of the raw water supply. As the hardness and salinity of the raw water increase above a certain maximum limit the efficiency of the softening mineral is reduced.

The effect of chlorides on the efficiency of zeolite softening mineral is well known and where there is possibility of marked rises in the salinity of the water to be treated, zeolite manufacturers qualify their guarantees in accordance with the anticipated salt content of the raw water supply. Equipment purchased under these conditions is sub-

ject to what is known as compensated hardness. This phrase indicates the reduction in the softening efficiency of the mineral as influenced by sodium salts in the raw water.

The influence of reduced softening efficiency of zeolite mineral resulting from high salinity in the water has been calculated for a specific set of conditions. These data have been plotted in figures 7 and 8.

Figure 8
Chart showing the Reduction in Softening Efficiency of Zeolite Mineral resulting from high Sodium Chlorides in the Raw Water



SELECTIVE TAKING OF WATER TO LIMIT THE SALT CONTENT

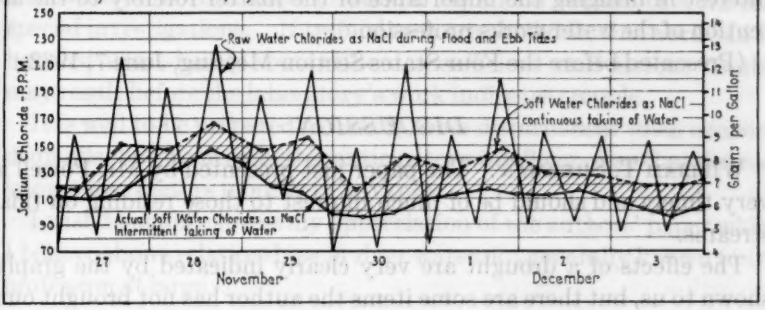
There are no practical methods for eliminating sodium chloride other than by distillation. This procedure, as previously indicated, may only be considered where the volumes of water to be treated are relatively small. Dilution of water which has been contaminated by salt, with water containing a lesser salt content or selective taking

of water at ebb tide, is a partial solution to the problem. Dilution of water is not always available, but selective taking of water is usually possible and requires merely sufficient storage and adequate pumping capacity to provide sufficient water, drawn at low tide conditions, to avoid the use of the more highly contaminated water at high tides.

One company using Delaware River water has provided adequate facilities for this purpose and the results of operation have definitely indicated the value of such procedure. This system has been in operation now for a number of months, and the results to date fully justify the investment required. The reduction in the salt content of the raw boiler feed water entering this plant has been plotted for a number of days in figure 9. There has been plotted on this curve,

Figure 9

Chart showing Reduction in Sodium Chloride Content of the Boiler Feed Water Supply resulting from Selective Taking of River Water in Comparison with Salt Content of Water during Continuous Pumping from the Delaware River at Intake, Bramel's Point, N. J.



also, the salt content of the water at high and low tides, the average amount of salt present in the water, if the water had been drawn constantly during the tide fluctuations, and the actual chlorides in the water delivered to the plant by selective draft.

CONCLUSIONS

The discussion of this paper has been limited largely to the influence of high salinity on the efficiency of zeolite softened boiler feed water. Many of the difficulties cited are pertinent to other forms of water treatment. There is close analogy between the treatment of boiler feedwater and softening the water for laundry and similar purposes, since the ultimate value of the treated supply depends on the residual hardness present in the finished product.

Chlorides, especially magnesium chlorides, have a marked effect on

the corrosive properties of water especially when the water is heated. It is extremely difficult to evaluate the influence of accelerated corrosion resulting from high chlorides, but there can be little doubt that these constituents do have a marked detrimental effect on the value of the supply. Heavy losses are also possible where water so contaminated is used for cooling purposes. This problem is especially important in the operation of high pressure steam stations, since the influence of small amounts of condenser leakage may be extremely costly where the cooling water is high in sodium and magnesium chlorides. Contamination of surface water supplies by salt water brought in by high tides is one worthy of careful study.

In the past, little attention has been given to the importance of industrial water supplies and their influence on the economic life in highly industrialized communities. It is the author's opinion that this Association may render invaluable service by taking an active interest in bringing the importance of the matter forcibly to the attention of the water works profession.

(Presented before the Four States Section Meeting, June 7, 1932.)

DISCUSSION

WILLIAM T. SHERMAN:[1] The paper just presented by Mr. Powell is very timely and should be of much interest to those residing on tidal streams.

The effects of a drought are very clearly indicated by the graphs shown to us, but there are some items the author has not brought out, possibly due to a desire for brevity.

He has shown the effect of chlorides on base exchange softener capacity, but in addition to this with a high chloride content in the raw water it seems impossible to completely soften the water passing through the softeners. There seems to be a selective action in the mineral which allows magnesium to pass through, or that a reversible reaction is present. This feature handicaps the boiler plant operator, making him resort to compensating internal treatment. The accepted method of phosphate treatment may possibly build up a deposit of magnesium phosphate which will cause tube failures. This has happened in several instances.

The effect of variable hardness caused by river flow and tidal action places a heavy burden on the softening plant. In actual operation

[1] Power Engineer, Vacuum Oil Company, Paulsboro, N. J.

one plant on the Delaware River will vary from 2 to 14 zeolite unit regenerations in 24 hours, due to seasonal changes. Five regenerations were considered the maximum when designed.

Another item the boiler plant operator faces is that of boiler feed capacity. With a change of 500 p.p.m. in total solids content of boiler feed, it is necessary to pump about 30 percent more water through the boiler feed circuit. This additional load may be beyond the design of existing equipment and cause serious operating hazards before necessary equipment can be installed.

The increase in silica content of your boiler feed water from 15 to 50 p.p.m. is appreciated by members who have high pressure boiler plants. A trace of silica may give serious silica scale trouble and turbine blade deposits.

Laboratory control of boiler water is more imperative when abnormal conditions arise and the normal number of laboratory assistants have to be increased to handle the added volume of work and special investigations. If trained men are available, this work can be handled immediately, but without a sufficient staff serious trouble may result before the laboratory's work indicates trouble.

It is well to be prepared to handle these disturbances when occasion demands, but we need better anticipatory intelligence so that we may know these factors months in advance.

I wish to again express my appreciation of the authors' paper which I believe shows relationships in river water not generally known to the profession at large.

ABEL WOLMAN:[2] The contribution by Mr. Powell on the relationship of salinity to industrial use of water, should be welcomed by the readers of THE JOURNAL. There is remarkably little information available in the literature of water works operation on the effect of salinity in this field of water supply. Even less information is at hand when dealing with critical concentrations of salt in domestic water supplies.

The U. S. Public Health Service standards for drinking water establish a maximum limit of 250 p.p.m. for chlorides as causing taste. The present writer established a similar limit for taste tolerance in the U. S. Supreme Court case dealing with the diversion of the Delaware River water. This conclusion was based on ex-

[2] Editor-in-Chief, The Journal of the American Water Works Association; Chief Engineer, Maryland Department of Health, Baltimore, Md.

perience in Maryland where it has been found that communities using deep well waters containing between 250 and 300 p.p.m. of chlorides, ordinarily turn to other sources of supply for drinking purposes.

Confirmation of the validity of this limit, at least in the eastern part of the United States, was presented during the drought of 1930, when the residents of the City of Havre de Grace, Maryland, who were accustomed to drinking a water supply normally containing less than 5 p.p.m., found their water supply gradually rising to a chloride content of 1000 p.p.m. Our experience indicated that the residents did not object strenuously to the drinking of this water until approximately 200 p.p.m. of chlorides was reached. As one of the housewives in this community remarked, "the water was excellent for cooking vegetables but not for drinking."

This community takes its water supply from the Susquehanna River, some distance above its mouth and some 8 or 10 miles below the power dam of the Susquehanna Power Company. During the drought conditions of 1930, salt water penetration affected the intake of the Havre de Grace water supply, particularly during that portion of the day when the Power Company was holding back the water above its dam in order to provide itself with sufficient water for the use of its turbines at peak demand. During this interval, at the suggestion of the State Department of Health of Maryland, water supply was taken from the Susquehanna River, which is tidal in this region, on a selective program. In other words, water was used from the Susquehanna River only at such times as the Power Company was operating its turbines, which made it possible to supplement the low water flow of the Susquehanna River by the turbine discharges of large amount. At the same time, the selective use was determined with relation to the ebb tides. By proper synchronizing of these various natural and artificial elements, it was possible to produce a water supply for Havre de Grace without excessive chlorides.

The plan which Mr. Powell suggests for supplementary fresh water storage has been used with considerable success elsewhere in this country, particularly on the Sacramento River, already described in THE JOURNAL.[3]

Although Mr. Powell did not refer to another contingency of salt

[3] Journal, March, 1932, page 325.

water penetration in fresh water streams, it should be mentioned in connection with his paper. I refer particularly to the damaging effect of salt water penetration on fresh water aquatic life, particularly fish. Our experience in 1930 indicated almost complete elimination of fresh water fish in normally fresh water streams, usually having chloride contents not exceeding 2500 p.p.m., when the chloride content rose to values in excess of 8000 to 10,000 p.p.m. Salt water types were noted in Maryland fresh water streams during 1930, some 65 miles further up stream then ordinarily found, with almost complete destruction of fresh water types.

METERING AT DURHAM, N. C.

By D. M. Williams

(*Assistant Superintendent, Water Department, Durham, N. C.*)

In 1928 the last flat rate account was erased from the books and ever since the Durham Water Department has been able to boast that it is 100 percent metered. This does not apply to the water consumers only, for from the time the rain is released from the clouds until it entered the consumers' premises, at each step, except fire protection, it is measured.

MEASURING AT SOURCE OF SUPPLY

Five rainfall stations are maintained over the watershed in addition to the two at the plants. This year a well gaging station was put into operation to measure the ground water storage. Four stream gaging stations measure the water entering the Lake and a fifth records that which passes down the stream below the dam. A recording gage gives a continuous record of the water level in the Lake. In 1926 one of the first evaporation gages ever to be placed on any Lake was installed on Lake Michie. Venturi meters measuring the water pumped to the filtration plant complete the cycle of water measuring at the source of supply.

Where continuous water supply is dependent upon impounding, however, as is the case at Durham, the study is not complete if silting is overlooked. Ten sections were made and referenced to permanent monuments before the Lake started filling in order that the loss in storage can be measured.

The installation and operation of these metering stations was made possible by the coöperation of the North Carolina Department of Conservation and Development, the United States Geological Survey and the Durham Water Department.

Some may think that all this measuring is useless expenditure of time and money, but such critics are probably not aware of the facts which show that Durham's water consumption this year is more than four times what it was twenty years ago, and that each consecutive

year has shown an increase over the previous one. During the month of September three times as much water was evaporated from Lake Michie as flowed into it and ten and one-half times the stream flow was pumped from the Lake. Had our predecessors' foresight been as good as our hindsight this measuring would have been started forty years ago.

METERING AT FILTRATION PLANT

At the filtration plant the water is metered before entering the coagulating basins and on passing into the distribution mains.

CUSTOMERS' METERING

In 1911 approximately 50 per cent of the customers' water supply was metered, by the end of 1926 this had increased to 78, in 1927 to 88, and before the end of 1928 the 100 per cent stage was reached.

It was not possible to get a separate meter on each individual house, for in many instances one person or firm owned two or more adjacent houses which were connected to the main through a single pipe which was installed by the property owner. In such cases a master or village meter was installed and the minimum rate charged for each individual house.

For example, water is billed quarterly and the minimum for each individual customer is $3.00 per quarter, for which 1333 cubic feet is allowed. The rate for the first 10,000 cubic feet is 22½ cents per hundred. Where a village meter controls 10 houses, the minimum bill for a quarter is $30.00 for the first 13,330 cubic feet or less. Should the meter register 20,000 cubic feet the bill would be $45.00 and 100,000 cubic feet would have to be used before the next lower rate becomes effective. In case one house becomes vacant, before the minimum can be reduced, the owner is required physically to disconnect the vacant house from the water supply and notify the Water Department. A department employee then makes an inspection of the property and if the proper disconnection has been made the account is revised.

The meter installation is paid for by the property owner, it is considered a part of the property and not transferable except when worn out or otherwise becomes obsolete or inadequate.

All 1½-inch meters and larger, and others where consumption is sufficient to justify it, are read every week. All others are read quarterly for billing. When a meter fails to register between readings

it is classified as dead and a repair tag is made out immediately. When the meter reading shows an abnormal registration either high or low it is re-read; first, to insure against erroneous billing; and second, to ascertain if it needs attention. In the event of abnormally large registration between the regular and the re-reading, the customer is notified in order that leaks can be attended to. There are about 280 meters on the weekly reading list, several of which register more than 350,000 cubic feet per week and quite a few register over 50,000 cubic feet per week.

After considerable experimeting we find that the most efficient meter reading crew consists of two men, one doing the labor and the other the paper work. Only one such crew is necessary as in an average day's work they will read some 350 to 400 meters. The reading period is from about the 15th to the 26th of the month. When not reading meters these men follow up complaints, make inspections and do various other routine work. Early in September these men were relieved of the weekly readings as this was turned over to the meter mechanic responsible for all meter repairing in the field. Marginal notes are made on the meter books when maintenance or repair work is found to be necessary. Repair cards are made out at the time the bill is calculated.

A recent tabulation of one quarter shows that of the 9369 active customers: 52.9 percent received minimum bills of $3.00, 4 percent —$3.15, 3.8 percent—$3.40, 3.4 percent—$3.60, 14.4 percent—between $3.70 and $4.95, 14.4 percent between $5.10 and $10.00, 4.4 percent between $10.10 and $22.50, 1.3 per cent between $22.60 and $42.50, and 136 or 1.4 per cent between $42.60 and $7500.00. Five customers pay more than $10,000 per year each, with the largest having water bills totaling $30,000 during this year of depression.

Realizing that "dead men tell no tales" every effort is being made to expedite repair work. This is no small job as is shown by the record of dead meters repaired in our shop during the past five years.

YEAR	NUMBER OF METERS REPAIRED	PERCENT OF TOTAL METERS INSTALLED
1928	760	9.2
1929	1,080	12.2
1930	1,120	12.3
1931	1,780	18.7
1932 (10 months)	1,240	13.0

In spite of this high percentage of casualties, when everything is considered, water meters are rather remarkable little gadgets. In this day of trials and tribulations the meter has not escaped, for some modern contraptions are like the thief in the night, they steal while the meter sleeps.

(Presented before the North Carolina Section meeting, November 1, 1932.)

FRICTION LOSSES IN BITUMASTIC LINED WATER PIPES

By Charles W. Sherman

(Of Metcalf and Eddy, Engineers, Boston, Mass.)

So little information is available upon the losses of head due to friction in water pipes lined with bitumastic enamel that it seems worth while to put on record the data obtained from a test made in Weston, Mass., in April, 1932, although the methods used were not well suited to accurate observations, and the short time available made it necessary to take many observations without waiting for stable conditions, so that adjustment of the observations had to be made. Individual experiments, therefore, are of little value, but the average results are believed to be significant.

The only similar data which are available, so far as the writer is informed, are those reported by Elson T. Killam in a paper published in the Journal of the A. W. W. A. for October, 1932, describing tests on pipe in the ground, including 5,490 feet of 12-inch pipe, and 12,264 feet of 10-inch pipe. The coefficient in the Williams-Hazen formula was found to be about 150, in which the effects of fittings, valves and changes of direction are included.

DESCRIPTION OF PIPE

The pipe on which the tests were made was 12-inch pit cast iron pipe in 12 foot lengths, and had an actual internal diameter of 11.71 inches. It was laid and put into service late in 1930, and the tests were made in the spring of 1932, so it had been full of water and in use for about 1½ years. The distance between the hydrants at which the pressure gages were located was 2,340 feet. In this length there are four 6-inch hydrant branches, three 6-inch branches serving a golf club, 1 plugged 12-inch branch, two 12-inch valves, and two 45° bends. The street in which the pipe is laid is winding, but all changes in direction are made in the pipe joints except for the two 45° bends noted above. The most important curves made by deflecting the pipes at the joints are one about 250 feet long with a radius of about 250 feet, followed almost immediately by another

in the opposite direction having about the same radius and a length of about 400 feet. In profile, the pipe falls continuously, but not at a uniform rate, from the upper to the lower hydrant.

The quantity of water consumed from this pipe, except by the golf club, is insignificant; and at the time of making the tests, the club was using no water on its greens and only a very small amount at the club house. Possible disturbances of flow by use of water, therefore, could not have affected the observations to a measurable degree.

METHOD OF MEASURING FLOW

Water was discharged from a hydrant some 500 feet beyond the lower hydrant at which pressure gage observations were taken. The discharge was through one or both of the 2½-inch hose nozzles, or through the 4½-inch steamer nozzle, whichever gave the most favorable conditions for gaging discharge by a hydrant Pitot. The hydrant valve was adjusted so that the combined effect of the throttled (or open) valve and the hydrant nozzles provided approximately the desired rate of flow. As soon as the rate of discharge appeared to be uniform, Pitot observations were taken from which the flow was computed.

METHOD OF MEASURING LOSS OF HEAD

The difference in elevation of the two hydrants at which the pressures were observed was determined by levelling to be 73.2 feet.

One calibrated pressure gage was attached to each hydrant at the ends of the section tested; and as it was impossible for the observers to know at what times the flow measurements would be taken or when changes in flow would be made, each gage was read at half-minute intervals unless there was so rapid fluctuation in pressure as to make it impracticable to get a significant reading. At the upper gage, the fluctuations were small, since this point was only about 200 feet below the 14-inch branch leading from the standpipe which provided the supply of water; at the lower hydrant, the pulsations resulting from the changes in flow were quite marked, and sometimes were still considerable when the next change of flow was made. Since only three men were used for these tests, and it was impossible for them to communicate with one another, this condition was not realized until the runs were completed. Therefore, it became necessary to chart the readings of the gage at the lower hydrant and determine from

the diagram what probably would have been the gage reading if the pulsations had ceased.

RANGE OF VELOCITIES

The rates of flow as determined by the hydrant Pitot ranged from 167 to 3,500 gallons per minute. The corresponding velocities in a 12-inch pipe ranged from about 0.5 to about 10 feet per second.

REJECTION OF EXPERIMENTS

The losses of head at low velocities were too small to be accurately observed on pressure gages read only to ½ pound; and the possible errors resulting from pulsations at the lower gage were so great as to render these observations useless. Therefore, it was decided arbitrarily to reject all tests in which the discharge was less than 775 gallons per minute (velocity about 2.2 feet per second.) Obviously, pressures higher than those corresponding to the static pressure can have resulted only from water hammer, and are of no significance except as indications of the extent of the pulsations resulting from closing the hydrant valve.

POSSIBILITY OF ERROR

The possibility of error in the adjustment of observations is still too great to justify putting much faith in individual experiments, but it is believed that the average of the coefficients obtained for the several experiments does provide a fair representation of the condition of the pipe surface.

SUMMARY OF RESULTS

A summary of the results of the several experiments during which the discharge was 775 gallons per minute or more is given in table 1.

The average coefficient in the Williams-Hazen formula is 167, using the actual diameter of the pipe. The range is from 124 to 203. If the observations in which judgment was exercised to a marked degree in adjusting the observations be omitted, the average is still 167.

Basing computations on the nominal diameter of the pipe, which would be used in problems of design, the average coefficient would be 158.

Making due allowance for the lack of precision of the methods used and for the adjustments of observations which were made where necessary, it is believed that these experiments confirm the

results obtained by Mr. Killam and quoted above, that the coefficient for a bitumastic lined pipe is at least 150; and, further, that there is no deterioration during a period of 1½ years in service.

TABLE 1

Coefficients in Williams-Hazen formula for 12-inch bitumastic lined pipe at Weston, Mass.

Tests made April 22, 1932, on pipe 1½ years old. Length 2340 feet. Actual diameter 11.71 inches. Pit-cast pipe in 12 foot lengths.

EXPERIMENT NUMBER	TIME	RATE OF FLOW, GALLONS PER MINUTE	CORRESPONDING VELOCITY IN 11.71 INCH PIPE, FEET PER SECOND	TOTAL LOSS OF HEAD, FEET	HYDRAULIC SLOPE, FEET PER 1,000	"C" (BY SLIDE RULE)	
						In 11.71 inch pipe	In 12-inch pipe
1	10.30	1,690	5.02	11*	4.70	166	156
2	10.31½	1,365	4.06	10	4.28	142	134
3	10.33½	1,148	3.41	8	3.42	134	126
4	10.35	905	2.70	6*	2.56	124	117
5	10.36½	835	2.45	4*	1.71	142	134
6	10.59	3,500	10.40	39*	16.7	174	164
7	11.18	2,350	7.00	17*	7.26	183	172
8	11.19½	1,940	5.76	11	4.70	192	181
9	11.20½	1,700	5.06	10	4.28	177	167
10	11.22	1,290	3.83	6*	2.56	178	167
11	11.23½	1,020	3.04	3*	1.28	203	192
12	11.25	775	2.29	2	0.85	192	181
Average						167	158

* These figures are more likely to be in error, because of adjustment of observations, than any others tabulated.

ACKNOWLEDGMENTS

Thanks are due to the Board of Water Commissioners of the Town of Weston, for permission to make these tests.

The field tests and the greater part of the computations and analyses of results were made by Howard E. Bailey, Assistant Engineer.

BOND ISSUE CAMPAIGN FOR NEW WATER WORKS IMPROVEMENTS AT LINCOLN, NEBRASKA

By D. L. Erickson

(*City Engineer, Lincoln, Neb.*)

On April 7, 1931, the voters of Lincoln, Nebraska, by a three to one majority authorized a bond issue of $2,300,000.00 for the purpose of obtaining a permanent water supply from the Platte River Valley in the vicinity of Ashland, Nebraska. This is the largest project that has ever been undertaken by the City of Lincoln and is a milestone in the City's history.

Lincoln's present water supply is obtained within the City Limits from 32 deep wells, divided into five groups, each group having its own pumping station. During the period from 1910 to 1930, the population of Lincoln has increased approximately from 55,000 to 80,000, while the water consumption has increased from 2.14 to 7.8 m.g.d.

The water level in the City of Lincoln's main group of wells receded 5 feet in 1930 as compared with an average of less than 2 feet per year for the preceding eighteen years. In addition, in 1930, the salt content of all the wells in one group increased to approximately 900 as compared with 27 p.p.m. in the remaining wells. This emphasized the fears that with the increased pumping and the increased draw down, the entire present supply might become salty.

Realizing the gravity of the situation, in May, 1929, the City Council by Ordinance created an Advisory Water Board which was to act in an advisory capacity to the Water Department and the City Council and to make recommendations as to necessary improvements and enlargements of the water works. This Board consisted of five members who were to be designated by the Superintendent of the Water Department and approved by the City Council, and were to serve for a term of six years without pay.

In selecting the members of this Water Board, the City was very fortunate in being able to enlist the services of five of its highest type citizens. The Chairman of this Board was the President of the larg-

est building and loan company in the City and a few years ago served on the City Council. One member was the head of our leading retail firm and a former Mayor. One was a leading real estate man. One was one of our largest real estate owners in the down town district and one a large manufacturer. It is significant that four of the five members of the Water Board are past presidents of our local Chamber of Commerce.

In 1923 and in 1929, preliminary reports on the water supply problem of the City of Lincoln were prepared by a firm of consulting engineers. In these reports consideration was given to obtaining our future water supply from seven different sources, all located outside of the City limits, ranging from 11 to 48 miles distance from the City. The estimated costs of these projects varied from 1.0 to 4.5 million dollars. In both reports, the Platte River Valley near Ashland was recommended as the future source of supply with an estimated cost in the 1929 report of 3.0 million dollars.

In 1930, as the water situation became more acute, attention was very forcibly directed by a group of our citizens to three additional possible sources, all located within six miles of the City. One of these was a surface supply project involving the construction of a dam and reservoir approximately two miles southwest of the City. The other two projects proposed the drilling of wells in the valleys of two streams of comparatively small drainage areas. In addition, a private development company very actively promoted a project guaranteeing to find a 12 m.g.d. supply within 12 miles of the City. This made a total of eleven possible sources of supply.

After several meetings and informal discussions, the Water Board decided that the proposition when submitted to the voters should specify definitely the source of supply that would be used. Thereby the voters themselves would definitely determine the source of supply and all questions as to source would be settled at the Bond Election.

Before making their recommendation as to the source that should be adopted, the Water Board felt that all the underground sources being given serious consideration should be further investigated by accurate test drilling to determine the quantity and quality of the water available. A well company was therefore engaged, who together with the City Engineer laid out a comprehensive testing program involving the making of 41 test wells. This well company filed a very detailed report showing their findings and recommended the so-called Ashland project.

Fortunately the services of the State Geological Survey located in Lincoln were available, which studied this problem from a geological standpoint and filed a very comprehensive report also recommending the Ashland Project.

From time to time, the City Engineer had occasion to make special studies and reports to answer questions that arose. In one case, it was felt that a certain source required very careful consideration by reason of the fact that it was located within two miles of the City Limits, and by reason of the active support given this source by friends of the owner of the land on which the wells would be constructed. A special report was made on this source, using the data obtained from the borings on this project and giving an estimate of the quantity of flow of underground water in the valley at this point, based on Turneaure and Russel's method. The quantity of flow available estimated in this report was 107,000 g.p.d. whereas the City was seeking a supply of 12 m.g.d.

The surface supply project near the City was stressed by a local engineer and received full publicity in the newspapers. The newspapers carried an article showing a plan map of the project and detailed estimates of cost. Emphasis was given to the fact that this project could be built for approximately 1.0 million dollars. Inasmuch as this project was proposed by a local fellow engineer, we felt that for this reason alone it should be considered and a special report was therefore prepared on this source. A study based on actual surveys disclosed the fact that basic data used by the local engineer, as obtained from the small scale United States Geological Survey Map, were inaccurate and misleading. Our estimate of cost of this project was $1,712,000.00 or an increase of 70 percent over the local engineer's estimate, largely due to the fact that it would be necessary to raise several miles of railroad tracks and relocate them a half mile farther east.

On the Ashland project, it was proposed to build approximately 25 miles of 36 inch pipe line, which would comprise 75 percent of the entire cost of the project. It was only natural that the size of this pipe line should be seriously questioned. In order definitely to settle this point, we prepared a special report, which showed that after balancing the annual differences in pumping cost based on the estimated increase in consumption against the fixed charges on the pipe line cost, the 36 inch pipe was the economical size.

Probably the most embarrassing question confronting us in the

campaign was whether or not it would be necessary to raise the water rate, in order to take care of the increased operating cost of the Water Department due to the new project. A special report was made on this question. The actual receipts and the operating expenses of the Water Department for the 20-year period just prior to 1931 were secured. For the 20-year period following 1930, estimates of the receipts were made based on the present rate and on the assumption that the increase in consumption during the next twenty years would be the same as had occurred during the past twenty years. The sinking fund was computed on the basis of distributing the same over the next twenty years in proportion to the estimated total annual quantity of water pumped. The interest was computed on the basis of 4 percent. The result of this study showed not only that the anticipated earnings from the Water Department during the next twenty years on the basis of the present rate would pay the interest and retire the bonds, but in addition a surplus of 2 million dollars might be expected to be accumulated.

By this time the Water Board had very complete information on every phase of the problem, including two preliminary reports by a leading firm of consulting engineers, a report by a well drilling company, reports by the State Geological Survey, report on the chemical analysis by the State University and several special reports prepared by the City Engineer. After careful deliberation, the Water Board prepared their report and recommendation on the future water supply, which was filed with the City Council on March 13, 1931.

In five carefully prepared pages, the Board stated their findings—that the present water supply was inadequate and in danger of becoming salty. The possible sources of future supply worthy of consideration were listed and the Board's opinion on each given. The report was concluded with the definite recommendation that the future water supply be obtained from the Platte River Valley near Ashland, with their reasons therefor.

This report of the Water Board was approved three days later by the City Council and a resolution was passed designating the Platte River Valley near Ashland as the site for the development of a permanent water supply for Lincoln. April 7th was the date set for the submission of the bond issue to the voters.

PREPARING FOR THE BOND ELECTION

Inasmuch as the Bond Election came on the same date as our regular City Primary Election, it was only natural that several of the can-

didates for City Commissioner should seize upon the Water Bond Program as an issue. Meetings were held by these candidates in various parts of the City during the second and third week preceding the election, at which they voiced their criticism of the Ashland Project and recommended other sources. However, there was no concerted organized opposition, the candidates being divided in opinion as to the best source.

The real work for the Water Bonds was done during the week immediately preceding the election when a very intensive campaign was carried on. This was led indirectly by the Chamber of Commerce which had already organized a carefully selected Publicity Committee and Speakers' Bureau.

A series of one-half page ads were published in the local newspapers the week before the election. 20,000 handbills were printed by this committee and distributed to every home in the City. These handbills were probably more effective than anything else in our bond campaign. They were about 18 inches square and contained on one side a clear map of the project, showing the location of the proposed wells, pumping station and pipe line. On this side also appears a sample ballot with instructions to the voter how to vote for the bonds. One-half of the other side of the hand bill was devoted to a series of questions and answers and the other half to a condensed statement of facts signed by the Members of the Water Board and the City Officials, together with a chart showing the chemical quality of the water and a chart showing graphically the result of the City Engineer's study of the water receipts and operating expenses which indicated that it would not be necessary to raise the water rate.

The Speakers' Bureau consisted of twenty of our leading young business men, who were furnished with copies of all of the reports, information and data available so that each speaker would be fully informed. During this week's campaign, members of this bureau made talks before the employees of all of the large business establishments in the City and daily talks over our three radio broadcasting stations. Both daily newspapers gave gratis considerable space, endorsing the bond issue and appealing to the thinking citizen to vote for the bonds.

During the last week, slides were shown at all of the moving picture theaters in the City. These were very effective and the applause resulting from the audience gave us the first indication that the Bond Issue probably would be successful.

The City Engineer was called upon to make talks at the meetings of all of the noon day luncheon Civic Clubs during the week of the intensive publicity campaign. At these talks, specially prepared large charts were displayed on the walls, showing the comparative merits of the various projects and all of the information that had been obtained.

The success of the Bond Issue marks the beginning of a new era in the City's history, as the shortage of water has always handicapped the growth of Lincoln. The decisive, favorable vote was very gratifying and indicated the confidence of the voters in the Water Board and the Water Department. It was a special tribute to the City Commissioner in charge of the Water Department who has served continuously in that capacity for the past eighteen years.

The preliminary reports herein referred to were made by Burns & McDonnell, Consulting Engineers at Kansas City, Mo. The drilling of the test wells was done by the Kelly Well Company of Grand Island, Nebraska. The geological reports on the problem by the State Geological Survey were made by Dr. Condra and Dr. Lugn. The chemical analyses were made by Prof. C. J. Frankforter of the University of Nebraska.

The work of preparing the plans and specifications for this project and the supervision of all construction is being handled by the City Engineer's office under the direct supervision of the writer and under the general direction of Mr. Wm. Schroeder, Commissioner of the Water and Light Department.

(Presented before the Missouri Valley Section meeting, October 30, 1931.)

IMPROVED COAGULATION AT THE RICHMOND, VIRGINIA, FILTER PLANT

By Marsden C. Smith

Engineer, Bureau of Water and Electricity, Richmond, Va.

Coagulation, as the term is used in water purification, at a rapid sand filter plant is the keystone upon which all other operations depend for their success. In many plants the cost of the coagulant exceeds all other operating costs. In Richmond improved coagulation has saved enough during the past year to pay all salaries, wages and operating expenses other than power and chemicals; and, in addition, the effluent has been greatly improved.

As a result of several years intensive study and experimental work in both the laboratory and plant operation, certain facts have been established, and others confirmed. These facts involve many different coagulants, temperature effects, the optimum pH and other such interesting features, but perhaps the most important may be approximately stated as follows:

(1) A minimum amount of coagulant is required for floc formation in a given water; and no amount or kind of mechanical treatment can overcome the failure to provide this minimum amount of coagulant.

(2) There is but one optimum quantity of coagulant required for a given water. The use of more or less than this optimum results in less successful coagulation and plant operation.

(3) That this optimum is much more sharply defined in cold than in warm water; probably being most pointed at that temperature at which the maximum density of the water occurs.

(4) That a sudden, even though very slight, change of pH immediately before the application of the coagulant, materially assists effective chemical reaction. With Richmond raw water this usually requires acid in summer and alkaline addition in winter.

(5) The losses resulting from inadequate mechanical treatment of the water after the application of the coagulant, were far greater than was realized.

(6) Probably the ideal mechanical treatment consists of:

(a) An immediate and thorough mixing of the applied coagulant. In many waters aeration here should be avoided.

(b) The floc must be kept in suspension a sufficient time.

(c) While in suspension, the floc must effectively, and under control as to violence, sweep throughout the mass of water.
(d) A proper return of a part of the settled floc and turbidity.

While the physical plant, constructed in 1924, was unusually well designed, it became evident from these studies that additional mechanical treatment of the water after the application of the coagulant, would materially improve purification results and economy. The disadvantages of the baffle type of chambers as a means of procuring this mechanical treatment were realized to include much loss of head, to lack essential flexibility and to be of relatively high initial cost. The machines that have been in operation more than a year were installed for less than one-fourth the estimated cost of comparable baffle chambers, produce virtually no loss of head and operate with a negligible expense. The principles involved were planned by the writer, and they were designed and supplied by the Dorr Company. They have been named the Flocculator, a name describing their function and differentiating them from other mechanical mixers.

The Richmond units consist of four horizontal shafts, the length of which are at right angles to the flow of the water. To these shafts are attached paddles to produce the motion of and prevent the settling of the floc for the greatest time shown by experiments to be desirable. The shafts rotate in the same direction, and this direction is such that the part of the paddles above the shafts move in the direction of flow, and that below the shafts against the direction of the flow of the water through the basins. Due to the relatively small velocity of the water through the coagulated water settling basins, the turning paddles create an outward travel to the stratum of water above the shafts, and an inward motion to the stratum below the shafts. It is evident that the rotation of the paddles is such that the outer edge of the last paddle is downward, while the inner edge of the first paddle is upward. Assisted by this downward motion of the last paddle, the settled floc soon forms a pile near the last paddle, and the current produced by the last paddle gently sweeps some of the settled material back along the bottom to the first paddle, where it is elevated by the upward motion and mixed with the incoming treated water. A weir constructed across the basin near the last shaft has the double advantage of assisting in the formation of the bank of settled material, and making it possible to continuously remove the surplus material, thus preventing the frequent interruption and expense of cleaning the basins.

In addition to the general circulation above described, the area between the adjacent shafts is in a constant swirl, due to the paddles there travelling in opposite directions, and so a very splendid motion of the floc results, which is in reality a swirling, twisting confusion, most effective in coagulation.

Each unit of four shafts is driven by a separate 3 H. P. variable speed, induction motor, which is connected through a suitable reduction gear to the first shaft. Each shaft is connected in turn, so that all shafts rotate at the same speed. The shafts may be rotated at any speed from one to three revolutions per minute, and the maximum power consumption of each set of four shafts is only 2.4 kilowatt-hours per hour. The degree of turbulence and floc return is controlled by the paddle speed, which is in turn controlled by the motor speed. The relative turbulence of any part of the treatment area is controlled by the paddle widths. Four units of these machines have been installed, one at the inlet end of each of the four coagulated water settling basins, or immediately following the original mixing chambers. The mixing chambers were constructed to be of the "around-the-end" type; but at the time the machines were installed, "over-and-under" baffles were added to the first seven of the ten passes. The four shafts of each unit of the machines are spaced 20 feet between centers, with 10 feet between the first shaft and the inlet end of the basin, and the circle of rotation is 8 feet 3 inches. The length of the shaft is determined by the width of the basins. Since the basins are from 52 to 72 feet wide, the retention in the treatment area is 70 minutes at the rated plant capacity of 30 m.g.d. This is in addition to the 10-minute retention in the mixing chambers, or a total of 80 minutes time between the application of coagulant and quiescence. This time is based upon 30 m.g.d. If less time is required, or if the plant is operated at a less rate, basins may be not used as desired. If, in future, higher rates are required, additional shafts may be added to give the same agitation period. Thus the flexibility of this installation is complete, both as to time and intensity of treatment.

At Richmond, variations in temperature, quantity of inhibiting colloids, turbidity, pH, and even wind velocity all have their influence both upon the quantity of coagulant that may be used and upon the results obtained. These variables, and others, are effective in a marked degree often in less than one hour. Also, the plant has to be operated differently to meet varying conditions; for example,

during the recent low water period the quantity of alum applied was increased approximately 0.7 grain per gallon above that which would have normally been sufficient because of the desire to remove as much as possible of the very objectionable materials then entering the raw water. Parenthetically it may be noted that the water temperatures were about at their seasonal maximum during this period. Finally, it is also certain that the splendid co-operation of the upstream manufacturers in materially reducing the quantity of objectionable trade wastes discharged into the stream, has assisted in the improved results.

COMPARISON OF RESULTS

Hence, a comparison of results obtained before and after the installation of the new equipment cannot be an accurate measure of their effectiveness, but such a comparison, supported by more exact limited tests, prove this equipment to be of remarkable value. In order to avoid two of the main variables in the raw water quality, the data below have been arranged to compare results when the temperatures and volume of stream flow have been quite similar. To aid comparison and to avoid excessive tabulation, certain plant operating results and other data have been averaged into two periods; the first, just before the machines were installed; the second period, since the installation. Both periods are for eleven months, or the entire time the machines have operated when this was written. The findings are shown in table 1.

TABLE 1

Average quality and operating results, Richmond filter plant, before and after installation of improved mechanical treatment

	RAW WATER TURBIDITY	RAW WATER COLOR	RAW WATER OXYGEN CONSUMED*	ALUM USED	FINISHED WATER COLOR	FINISHED WATER OXYGEN CONSUMED*	FINISHED WATER ALUM	PERCENT WASH WATER
	p.p.m.	*p.p.m.*		*g.p.g.*	*p.p.m.*		*p.p.m.*	
1 period	53.13	46.85	13.50	4.58	5.46	4.46	0.26	1.31
2 period	70.79	41.12	7.48	2.78	3.96	3.10	0.06	0.59

* Permanganate Digestion, A. P. H. A. Standard Methods.

It should be particularly noted that the alum required, in spite of

the previously mentioned excess used during the late summer of the second period, has averaged 1.8 grains per gallon less than before the machines were installed. At present prices, this alone has resulted in an estimated saving of more than $23,000.00 in twelve months, or approximately $5,000.00 more than the installed cost of all machines. But of even far greater importance, the quality of the finished water is shown to be vastly improved, the filter capacity increased and the wash water requirements reduced by more than one-half.

During the year, many interesting and unexpected demonstrations of the effectiveness of the machines have occurred. Since the flocculators were briefly described and the results of the first four months operation were presented in an article by the writer in Water Works and Sewerage for April 1932 and on account of the limited time, only a few of these will be mentioned.

SPECIAL ADVANTAGES OF FLOCCULATOR

Operating difficulties formerly were most acute during times of low stream flow at either low water temperatures or at relatively high temperatures. The effects of combined low flow and temperatures were the formation of a large, but light, feathery and fragile floc; so light and feathery, as to settle but little in the basins provided. But, of greater seriousness, the floc was so fragile that it would return to colloidal state in passing through the necessary restrictions, such as gates, etc., and so, pass with but little reduction through the filters. The combinations of low flow and high temperature resulted at times in practically a complete failure to floc, and this often resulted with doses in excess of 6 grains per gallon. These conditions have been so improved that at no time has any badly prepared water been obtained except during periods of sudden change of raw water quality, temporarily shifting the optimum dosage.

During the summer, tests, to determine the most effective speed of rotation of the machines, were made. It was believed, that, the higher temperatures causing more rapid floc formation, the lowest machine speeds would prove most beneficial. On the contrary, these tests proved that for efficiency the speeds must be kept at almost the maximum. The writer considers this an admirable demonstration of the effectiveness of the feature of returning to the incoming treated water a part of the settled turbidity and alum; a feature carefully provided for in the design of the machines. At the

minimum speed the agitation is sufficient to prevent the settlement of the floc until past the machines, and to produce ample floc motion. But at such low paddle speeds, the return of the lower stratum of water was probably prevented almost entirely, by the outward flow of the whole mass of water. At the higher paddle speeds, the greater lower stratum velocity produced the desired recirculation.

A further indication of the value of this feature is found when first using a basin after being drained and cleaned. Until sufficient time has permitted the formation of a bank of settled material beyond the last shaft, either the quantity of alum must be increased or a decidedly inferior coagulated water will result. This return of previously settled material results in what has been estimated at from 0.25 to 0.5 grain per gallon, or from 700 to 1400 pounds of alum per average day at this plant.

Again, an interesting but unintentional experiment was recently made. The motors of these machines are protected by thermal relays. During one of the summers hottest days, the sun's heat caused the motors of basins one and two, which were then operating alone, to act, stopping the machines. After a while, inspection discovered the condition, and the machines were again started. No change whatever in plant operation or alum applied was made, but the small band of apparently uncoagulated water passed on through the basins sandwiched between the clear water obtained before and after the machines stopped. This fortunately small band of water went on through the plant, filters and all, in its apparently untreated, unfiltered condition.

And so, improved coagulation at the Richmond filter plant, has not only greatly reduced operating costs and increased plant capacity, but provided a water that before filtration has much of the time been superior to the filter effluent of past years.

(Presented before the North Carolina Section meeting, November 2, 1932.)

OPERATION OF THE LAWRENCE, KANSAS, PURIFICATION PLANT

By C. T. Hough

(*Superintendent, Water Works, Lawrence, Kans.*)

The Lawrence water purification plant was placed in operation in 1917. The supply was obtained from wells located on the west bank of the Kaw River. The flow from the wells soon became inadequate and a year later the supply was taken from the river. Coagulation and partial softening with lime was carried on simultaneously until April, 1927, when plain sedimentation and coagulation was begun in new basins constructed west of the softening plant. During the summer season of that year efforts were directed mainly to determine the efficiency and amount of coagulants necessary for these basins at various turbidities. Due to inadequate reservoir capacity the rate of flow through the basins and softening plant has been extremely variable, the rate ranging from 700 to as high as 2200 g.p.m. during a 24 hour period. The ultimate efficiency could therefore not be obtained and close observation was imperative to maintain the amount of coagulant to a minimum. Rapid changes in turbidity are typical of the Kaw River, the amount varying from 400 to 8000 p.p.m. within a few hours period. Turbidities of 12,000 to 16,000 p.p.m. are not unusual during the rainy season and the plant has removed turbidities of 60,000 p.p.m. without difficulty. With these conditions turbidity tests have been necessary every two to four hours depending upon the condition of the raw water.

The average detention period of the plain sedimentation basin is 4½ hours, and of the combined reaction and coagulation basin 10 hours. The turbidity removal by plain sedimentation has averaged 67 percent during the past four years, and of the remaining 33 percent, 29 percent was removed by coagulation.

Coagulation has been carried on almost entirely with aluminum sulphate with an addition of one-half quantity of hydrated lime for better floc. Ferrous sulphate was used for a thirty day period last year and resulted in better floc with less dosage than the alumi-

num sulphate. Only 0.33 grain of lime was necessary per grain of ferrous sulphate for good coagulation. Mixing the chemicals for coagulation is accomplished by a rapid spiral motion of the water around a down-take pipe from which the water passes to the reaction basin. This method of mixing which eliminates any form of mechanical agitators has proven very effective. Aluminum sulphate for coagulation has averaged 1.47 grains per gallon during the past four years.

SOFTENING

The softening process has presented some very interesting problems the past few years, especially during treatment at low temperatures. The alkalinity of the raw water varies from 125 in the summer season to 300 p.p.m. in winter. The sulphate hardness is 50 to 125 p.p.m. during these seasons respectively. Softening has been carried on with hydrated lime. In attempting further softening with lime about four years ago positive bacterial results appeared when the water temperature lowered to approximately 40 degrees Fahr. As there is no collecting pipe from the filters to the clearwell, chlorine has been applied to the pump suction. Samples taken along the main feeders to the city were found to be positive along the first 1½ miles from the plant, and beyond this point they were negative. Increasing the alum dosage for filter floc would tend to correct this condition, and the results indicated a lack of sufficient detention period with water of high pH. An additional chlorinator was at once obtained for applying chlorine to the lime basin influent providing further detention for the action of chlorine and negative bacterial results were immediately obtained.

TASTE AND ODOR

The usual tastes due to algae, dead leaves, and chlorine have been evident at various times with this supply. Ammonium sulphate treatment was begun in April, 1931, and additional equipment also added for recarbonation. Prior to the addition of the ammonium sulphate, chlorine could be applied to the filter influent with only the 3 hour detention period in the clear well, but with the application of ammonium sulphate a further detention period was found to be necessary. This was obtained by transferring the application to the lime mixing basin providing an average detention period of about 8 hours with one hour interval between applications of ammonium

sulphate and chlorine. This detention period was found to be ample for good operation. One-half pound available ammonia per pound of chlorine has given the best results with this treatment which is equivalent to 8 pounds ammonium sulphate per million gallons.

Very good results have been obtained with the ammonia-chlorine treatment. Chlorinous tastes have been practically eliminated. No complaints from consumers have been made when troubles from algae occur. For a ten day period during August, 1931, unusually heavy odors from decaying algae were noted in the plant. No tastes accompanied this condition due to the ammonia treatment and no odor was evident in the mains. Residual chlorine may be maintained at 0.4 to 0.5 p.p.m. with no apparent tastes. Effect of the chlorine is lost, however, if 0.1 to 0.2 p.p.m. residual is not maintained on the filter influent for sufficient detention before the water reaches the consumer. A chlorine dosage is also applied to the pump suction for additional protection.

RECARBONATION

Recarbonation has been carried on with very satisfactory results. The equipment consists of a gas burner, coke scrubber compressor, condensation trap, and manometer for measuring the rate of flow of gas. Some difficulty occurred prior to the construction of a storage reservoir due to the varied rate of flow through the plant. The varied flow prevented a uniform causticity resulting in lack of uniform rate of recarbonation. Considerable precipitates were carried onto the filters as sufficient detention was not available for their removal. Only $1\frac{1}{2}$ hours detention period could be obtained between the CO_2 grid and the final filters. After the construction of the reservoir a uniform flow through the plant was provided and the precipitates carried onto the filters have been maintained sufficiently low for fair filter operation.

Recarbonation has assisted materially in better clarification and lower alkalinities. Since the installation of the recarbonation equipment alkalinities have been maintained at 30 to 40 p.p.m. of which 4 to 8 parts are normal carbonates. The total hardness of the treated water is 80 to 100 p.p.m. The pH varies from 8.4 to 8.8.

GENERAL DATA

The duties of chemist and bacteriologist are carried on by the Superintendent and time is therefore limited for laboratory work.

Much depends upon the close attention of the operators who make turbidity and alkalinity determinations on samples taken at 6 locations of treatment every 2 to 4 hours. Additional hardness and bacterial analyses are run daily.

The average daily consumption is one and one-half million gallons. Eighty to 85 pounds pressure is maintained at the plant and the same pressure is provided by a booster station for the higher elevations adjacent to the University.

From the results of operation during the past five years the following conditions are evident with this supply. Ample detention period must be obtained for good bacterial results with partial lime treatment at low temperatures and high pH. The action of chlorine is retarded by the application of ammonia and longer detention period is necessary if the ammonia treatment is used. Ample detention period should be obtained if possible between the CO_2 grid and the final filters. With these conclusions in mind changes have been made for combined coagulation and softening in the coagulation basin. With this arrangement the water enters the present softening plant with a causticity of 10 to 20 p.p.m. The CO_2 grid is now located in the lime reaction basin which provides an 8-hour detention period after recarbonation.

A sludge pump installed at the time the plant was constructed is now available with practically no change in piping for the use of sludge return treatment if desired. The sludge return treatment was impractical prior to these recent changes due to the high organic content in the softening basin. The new plan of operation should fulfill every desire for proper chemical reactions herein mentioned.

(Presented before the Missouri Valley Section meeting, October 29, 1931.)

THE SYRACUSE WATER WORKS

By Marshall B. Palmer

(*Consulting Engineer, Syracuse, N. Y.*)

The City of Syracuse was settled soon after the Revolutionary War and became a City in 1847 when the population was about 21,000.

There was much agitation for a public water supply in Syracuse as early as 1825 but it was not until 1841 that a "string of logs" was laid from springs in the eastern part of the city to the business section. Considerable mention is made in local history of the first reservoir, a structure some 6 feet by 8 feet by 12 feet. Later on cisterns were placed about every block along the main "strings of logs" and at times of fires hand operated engines boosted the flow from cistern to cistern toward the fire. There was often great endeavor to flood the cistern ahead of a pump thus indicating superior pumping ability. Early in the 40's a private Water Company began to function and continued until bought out by the City in 1892. This company supplied spring water from three large springs for about fifteen years when it was necessary to supplement them by water from other sources. In 1864 they built a large 170,000,000 gallon reservoir on Onondaga Hill, four miles southwest of the city. It had a watershed of only two square miles and all summer long the streams were dry and the reservoir dropped so low that the decaying vegetation gave the water bad odors and taste. About 1870 they built a pumping plant on Onondaga Creek, which flows through the City, and a 54,000,000 gallon reservoir known as Wilkinson Reservoir. This reservoir was 110 feet above the City. The water was too hard and was reported as impure. Some ten to fifteen years later there developed a strong sentiment for a better water supply and J. J. R. Croes of Boston was engaged to study and report on the best available supply. He found eleven possible sources and selected Skaneateles Lake as the most desirable, in fact, as very desirable. The other sources were Lake Ontario, 38 miles away and 150 feet lower than Syracuse; Oneida Lake 12 miles distant and 30 feet below; Otisco, Cazenovia

and Tully Lakes; Seneca and Salmon Rivers and Onodaga and Butternut Creeks.

In 1889 the city voted almost unanimously to buy out the old water company and build a new supply from Skaneateles Lake.

The old plant consisted of about 40 miles of mains in 172 miles of streets, considerable land, a pumping plant and three reservoirs. Most of the mains were only 4-inch and badly choked up. None of the reservoirs were suitable to include in the new system, yet the condemnation commission saw fit to place a value of $850,000 on the old plant and the city took it over in 1892 and operated it until the new supply was available two years later.

PRESENT SUPPLY FROM SKANEATELES

Much opposition developed against taking water from Skaneateles Lake, the three principal opposers of which were the State for the operation of the Erie Canal, the 40 water powers along the outlet and the Village of Skaneateles. The State finally consented on the condition that the storage be increased by a quantity sufficient to supply the city, the water powers were all purchased outright at great cost and sewers were built for the village.

The lake lies 19 miles southwest of the city at an elevation of 460 feet above the city. It is 15 miles long, from 20 to 300 feet deep and has an area of 14 square miles and a watershed of 60 square miles. The run-off for the past ten years has ranged from 50,000,000 to 90,000,000 gallons per day. The water is especially clear, cool and palatable, of average hardness and free from pollution. The shores are bold and rocky and contain no swampy places. One foot of storage on the lake will supply the city at present for about three months. A high water mark at the outlet dam was established many years ago and property owners on the lake bring suit if the lake is raised above this elevation. With present conduit capacity it is possible to flow sufficient for summer consumption when the lake is about four feet below said high water mark. To provide for future increase in consumption it is planned to acquire the right to raise the water two and one-half feet higher than this mark and to lay a 48-inch conduit from the lake to Willow Glen a distance of 8200 feet. This latter increase in the conduit capacity together with a second intake pipe will permit a flow of 60,000,000 gallons per day to the city with the lake seven feet below the new high water mark.

Rainfall records are kept at each end of the lake and show quite a

variation in summer rains. Some quite severe thunder storms do not extend the full length of the lake. The average rainfall at the north end of the lake is 40 inches and ranges from 30 to 48 inches.

The pH value of the water is slightly above the neutral point and as it contains some lime which forms a very thin coating the corrosive action on conduits is very slight. Examination of the inside of Conduit No. 1 shows almost no tubercles after 38 years in service. Flow tests show no decrease in velocity. The dam controlling the outlet was built by the city in 1893 and is a masonry structure 17 feet high and 145 feet long with suitable wing walls and six sluice gates for controlling the flow through the dam. These gates are used to control the elevation of the lake and up to 8 years ago they were operated by the State Canal officials for feeding the Erie Canal. Since the construction of the State Barge Canal some 12 years ago the State has permitted the City to operate these gates and the lake is maintained at spring run-off about a foot below the established high water mark. In dry seasons the lake drops four to five feet below this mark and at such times there is barely sufficient head to overcome the friction loss in the long intake.

Records of the run-off of the lake both to the city and down the outlet are kept. Measurements at the dam are now made by recording electrical instruments actuated by the loss of head in passing steel diaphragms or "orifice plates" located in 24 and 48 inch concrete pipes extending a few feet down stream from the sluice gates in the dam. Summer flows are measured in the smaller pipes and spring or flood flows in the larger pipe or in both. Flows to the City are measured by recording pitometers both at the lake and at the reservoirs.

INTAKE

The intake was built in 1893 of $\frac{3}{8}$-inch steel, is 54 inches in diameter and 6419 feet long. At the outer end is a timber crib 16 feet square and 12 feet high placed on a foundation of small stone. It is divided into several compartments, all but one of which are filled with stone. In that one is a screen over the end of a steel reducer elbow. The water enters from the top and passes into the 54-inch pipe through this elbow and a flexible joint. The water is 40 feet deep around the intake and the screen is about 14 feet above the bottom. The water is very free from any silt or floating matter even at times of high winds.

At the north end of the lake the water is only a few feet deep and gradually increases to 25 feet in depth three quarters of a mile from shore.

A trench was dredged with a dipper dredge to a depth of 15 feet at the shore end and the trench gradually decreased in depth to nothing three quarters of a mile from shore.

The pipe is riveted, has telescoping joints and was put together into 116 feet sections on shore floated to position, lowered from a catamaran 95 feet long and joined by divers to the last pipe laid by means of hook bolts. These joints were slightly flexible and about 1000 feet apart were placed special spherical flexible joints. The pipe was coated with asphalt coatings applied by two dippings and until recently it has resisted corrosion fairly well. The increasing summer consumption is rapidly approaching the limit of flow of the existing intake especially when the lake is low. At these times the pipe barely flows full at the gate house which means that the inside pressure is reduced to zero while the pipe carries a heavy overload of earth at the shore end, and thus there is some risk of a collapse. Plans have been prepared for a new intake to be of 54-inch gunite pipe. The 200 feet in deep cut between the gate house and the lake shore has been laid with 60-inch cast iron pipe. The new intake will be only 4400 feet long. This will leave the outer end in about 22 feet of water and if not as satisfactory as the other one which is in deeper water it can easily be extended 2000 feet to where the water is 40 feet deep. The gunite pipe will be shot against a vertical collapsible form to a thickness of 3 inches and reinforced with an inside and outside cage of wire mesh together with longitudinal rods for holding the cast iron ends in place. These ends are designed with male and female machined joints so that they can be bolted together under water similar to Universal pipe. It is planned to use 25 feet lengths and float them to position by placing a large light-weight steel cylinder inside of the pipe and filling it with air until its buoyancy floats the pipe. The cylinder will be divided into compartments to prevent the air and water in the cylinder from rushing to one end.

A motor boat will be used to tow the floating pipe from the shore to the trench and will be provided with a small air compressor and air storage tank with hose leading to the floating cylinder. It is planned that, when the pipe is floated over the position it is to occupy in the line, by releasing a little air from the cylinder the pipe can be very easily settled to position and the joint bolted up by divers. A steel

cross will be bolted to the outer end of the pipe and will rest on two to three feet of coarse crushed stone. The three open ends of the cross will each be 60 inches in diameter and have ¼-inch screens bolted in position. Three scows have been built and on two of these it is planned to float the City's caterpillar tread excavator and do the trenching with a clam shell bucket. These scows will then be used for laying the pipe. The pipe will be furnished by contract and the trenching and laying done by city forces. The Water Division has a diving outfit which will be used in helping lay and inspect the submerged pipe.

The Water Division owns a gunite machine and has used gunite in many places besides lining the new large Westcott Reservoir with it last year. (For description of this work and results of many tests of gunite under varying conditions see article in JOURNAL, volume 23, page 2110, 1931.) During the past winter about 800 feet of 48-inch gunite pipe was constructed and laid with bell and spigot joints, thus proving that it is a feasible material for a water conduit.

SKANEATELES GATE HOUSE

The Skaneateles Gate House is located 200 feet from the lake and contains masonry wells 25 feet deep. The intake enters the upper well from which the water flows through sluice gates to the lower well which is divided by a steel diaphragm separating the flow into Conduits # 1 and # 2. One-quarter inch mesh screens are located in the lower wells. The new intake will enter a new well, to be constructed adjoining the existing gate house. It will contain screens and sluice gates and discharge into the 3rd Conduit when extended to Skaneateles. It is planned to remove the old gate house superstructure and build a combined gate house and an attractive and modern keeper's home over the combined system of wells. Bids for this work have been received, but the work is held up pending better financial conditions for floating bonds.

TREATMENT OF WATER

The only treatment given the water is with chlorine gas which is done by means of two modern chlorinators either of which is capable of functioning separately. The gas is mixed with water and fed into the water, formerly into the upper well, but trouble was experienced in getting a uniform quantity to each conduit so that now it is fed into the intake pipe 125 feet before it reaches the gate house. Tests for excess chlorine are made twice daily. The quantity used is

checked by weighing the containers and recording the loss in weight per day. About 50 pounds of liquid chlorine are needed to treat 30,000,000 gallons of water. This varies slightly with the organic matter existing in the water.

CONDUITS

Extensive surveys were made of all practicable routes for conduits from the lake to the distribution reservoir at the City. Contour maps were plotted from which a final location or route was selected.

The valley forming the outlet of the lake has a very flat grade and the only location for a gravity conduit is along this outlet. The law permitting the city to take Skaneateles water restricted the size to 30-inch. The rate of grade of the hydraulic gradient is 2.35 feet per 1000 and in order to lay the pipe below the said hydraulic gradient the trench was from 20 to 30 feet deep through quicksand and close to said creek. So great difficulty was experienced in trenching that the contractor threw up the job and the city finished it by day labor at great expense. Before starting the second conduit in 1909 the law was changed to permit a 42-inch pipe which was laid in the upper 7500 feet. The balance of the conduit is of 30-inch pipe. The larger pipe permitted laying to a much flatter grade, thus greatly reducing the depth of cut through the quicksand and no special difficulty was experienced.

A right of way, generally 60 feet wide, was acquired for the first conduit and the pipe laid on the center line. The second conduit was laid parallel and about 15 feet to the south of the first and the third an equal distance on the other side. No. 1 was laid mostly during the year 1893 and No. 2 during 1909. Both are of cast iron and are provided with blow-offs at all low points, air valves at all summits, gate valves about two miles apart, manholes a half mile apart, cross-overs in five places and the lines are about 19.25 miles long.

The pipes are designed to withstand lake pressure when valves are closed at the lower end. This gives heads of from 15 to 480 feet and calls for pipe 1.5 inches thick at the low places. At the upper end it is $\frac{7}{8}$-inch thick and $\frac{1}{16}$-inch was added for each 35 feet of increase in head. All joints in conduits I and II were made of lead poured hot and calked and subjected to pressure tests before the joints were back-filled. On section I of conduit III the joints were made of Metallium and on section II Leadite was used.

In 1921 there was a shortage of water and instead of laying an entire new third conduit a 6 mile section was laid at the upper end and

crossed over into the first two at three places. It was estimated that two 30-inch lines and one 36-inch one would carry all the water the city would be allowed to take from Skaneateles Lake so the third line is to be of 36-inch diameter, except the upper 8200 feet along the above mentioned outlet where a 48-inch line will be laid on a flatter grade as in No. 2. This six miles section of No. 3 lifts the hydraulic grade at the lower end sufficient to increase the flow to the city by about four and one-third million gallons per day. Likewise in 1927 when still more water was needed, a second section of No. 3 was laid and connected in to the first two at its lower end.

About half way from the lake to the city Conduits 1 and 2 are located along a very steep and rocky hillside for about a mile which is known as the "Alps." Most of the trenches here are in solid rock which contain many faults and seams. About 1925 a 100 foot section of Conduits 1 and 2 settled one to two feet. No pipe broke, but joints pulled partly out and leaked. The crevasses in the rock for many feet down were filled with concrete and the conduits raised to the original grade and supported on concrete piers—two to each pipe. Conduit 3 was laid on the opposite side of the valley past this place, thus avoiding considerable expensive work.

DISTRIBUTION RESERVOIRS

As none of the three reservoirs acquired from the old Water Company were adaptable for use in the new system a new one was constructed in 1893–5 and named Woodland Reservoir. It is located two miles southwest of and 220 feet above the business center. This gives a pressure of about 90 pounds per square inch.

It is kidney shaped, bounded by four graceful curves, 35.75 feet deep, lined, has an area of 14 acres and holds 125,000,000 gallons. Water enters through a gate house near the south end and leaves through a similar structure at the north end. The lining consists of a single course of 9-inch concrete hand mixed concrete proportioned 1–2–3 using "American" cement on the bottom and part way up the slopes, which are 1 on 2. The upper two-thirds of the slope is surfaced with a 6-inch layer of concrete beneath a 12-inch slope wall carefully laid in cement mortar.

This reservoir has been in continuous service since 1895 and has been fairly watertight. The reservoir is in part excavation and part embankment, the material being a stiff clay and hardpan. Last winter a leak developed at the north end where the embankment is

about 42 feet high and the reservoir was at once emptied. Only three to four inches of silt were found in the bottom.

Repairs to lining

The concrete lining was found to be in a fair condition generally, but at the front angle of the ten foot berm had cracked and pushed open somewhat and there were several joint cracks. A 6-inch core was cut from the old lining and tested for porosity and found that at 15 pounds pressure the leakage was very appreciable.

The city is now relining this reservoir with a 1½ to 2-inch course of gunite by city forces. A complete equipment has been rented from the Cement-Gun Company of Allentown, Pa. Four inch by 4-inch by No. 7 wire mesh will be bolted to the old lining with ¼-inch by 4-inch expansion bolts. The total area of gunite will be about 700,000 square feet and the cost about $100,000.

Piping and valves

There are four gate houses at this reservoir and a very complete system of valves and crossovers permitting any change in flow that it is desired to make, water can be drawn from the bottom or the center of the reservoir and it is possible to by-pass the reservoir entirely and turn the conduit flows into the distribution system.

Westcott reservoir

In 1931 a second distributing reservoir known as Westcott Reservoir was completed and placed in service. It has a capacity of 108,000,000 gallons, is 35 feet deep and is located just west of the city and is about a foot higher than Woodland. It is built on a hilltop partly in excavation and partly in embankment. The lining is of gunite 3½ inches thick with expansion joints spaced about 130 feet apart. On the side slopes, which are one on two, a 6-inch layer of crushed stone was placed under the lining and the upper 20 feet of gunite is protected from the weather by a 6-inch course of rubble limestone masonry. A drain under the lining, at the foot of the slope, conveys away all leakage and shows the extent of the same. This averages about 30,000 gallons per day which is comparatively small considering the depth of the water and large area of the lining. The inflow is through a 42-inch main laid in tunnel under the embankment and extending along the bottom of the reservoir on piers to an aerator located near the north end. The aerator can be by-passed by

means of a 30-inch Ross Valve located in the aerator and provided with remote control through copper tubes leading to the gate house.

The outflow is through a 48-inch main 8200 feet long leading to the distribution system in the factory section of the City. The two gate houses are well provided with automatic and hydraulically operated gate valves, crossovers, screens and recording flow meters. Both reservoirs are surrounded by high wire mesh fences. The grounds have been graded and plans prepared for landscaping. Westcott Reservoir is fed by a 42-inch conduit 4600 feet long leading from the conduit lines at Andrews Gate House. This house is located 9500 feet toward the lake from Woodland Reservoir and is provided with a complete set of valves and crossovers. When the third conduit is completed it will flow direct to Westcott Reservoir, Conduit No. 2 will supply the High Service and Conduit No. 1 will feed Woodland Reservoir. Both reservoirs serve the low service.

HIGH SERVICE

About 1905 new tracts began to develop on the higher lands in the City and in 1909 a high service was established. This has grown until it now includes an area of 6.5 square miles and the water consumption is about 4,000,000 gallons per day. The first storage was provided in 1910 when Woodland Standpipe was completed. This consists of a steel tank 66 feet by 51.75 feet holding one and one-fourth million gallons of water and is encased in a brick and stone casing tower of pleasing design. This standpipe "floats on the line" as Conduit No. 2 flows direct from the Lake to the high service. An overflow in the tank empties into Woodland Reservoir which is 108 feet lower. As the greatest consumption on the high service is in the University section a second standpipe was constructed there in Thornden Park in 1925. This tank is 77 feet by 60 feet and holds two million gallons. It is also encased in a similar brick and stone tower. This tank fills up in the night and helps maintain better pressure at time of maximum consumption next day. When there is a shortage of water to the city, Conduit No. 2 is flowed direct into low service and such water as is needed for high service is pumped from low to high service. Two centrifugal 8-inch pumps operated by electric motors are available for this purpose at all times. One is located at Woodland Reservoir and the other at the Beech Street Shop in the eastern part of the city.

Woodland Standpipe was sandblasted and the inside including bot-

tom, coated with a 2-inch layer of gunite last winter. Holes were drilled into the steel tank and tight fitting ¼-inch bolts driven in and bent over the wire mesh to support it.

Wire mesh was used and the gunite was mixed one part cement to three parts sand.

Thornden Standpipe is coated on the inside with Hermastic Enamel and on the outside with bitumastic primer and paint.

DISTRIBUTION SYSTEM

The distribution system consists of 375 miles of cast iron pipe ranging from 48 to 6-inch in diameter most of which has bell and spigot joints, the balance being Universal Pipe. Six inch pipe is the smallest size used for mains. Up to a few years ago joints were made of lead, but recently joint material compounds are used.

The City is amply supplied with large size feeders so that the residual head remains a large per cent of the static. Gate valves are installed at all street intersections and hydrants average about 300 feet apart. A few new streets have two mains and a few others have a second main where the buildings are close together. Single mains are laid 8 feet off the center of the street.

Meters

The City is fully metered including public buildings but no charge is made for water for fires or municipal use. Property owners own their meters. The city inspects and repairs at owners' expense.

Services

Lead pipe was used for services under 2 inches in diameter until a few years ago. Now copper pipe is used and is very satisfactory. The city makes taps and lays services free to the curb.

Water shop

The City built and equipped a large and up to date shop three years ago. It is equipped with a garage to house the 24 trucks and 6 automobiles, an auto repair, blacksmith, plumbing, carpenter, machine and meter repair shops, stock rooms, engineer and accountants offices, testing laboratory and stock yard with railroad siding and large overhead travelling crane. A full line of machinery is carried such as several trenching machines, backfillers, portable pumps, air compressors, tampers, tapping machines, etc.

Water waste survey

The City maintains a fully equipped water waste survey party and makes regular surveys and tests for leaks. Many sizeable leaks have been located and repaired.

RATES

Domestic rates for water are $6.00 per year with an allowance of 5000 cubic feet per year. Excess is charged for at 12 cents per 100 cubic feet. Large consumers pay 12 cents per 100 for the first 10,000 cubic feet per month and 6 cents per 100 for all over this amount.

GENERAL DATA

The population of Syracuse is 219,000 (1932). For many years the increase has averaged $2\frac{1}{3}$ percent per year compounded. The area of the city is 25.6 square miles. The business section is 400 feet above sea level. Skaneateles Lake is 460 feet above said business section. The per capita consumption is about 150 gallons per day when factories are all operating. The normal consumption is about 33,000,000 gallons per day. The Park Department operates several large swimming pools which require much water in warm weather.

Up to a few years ago the water had the usual bad odor and taste in summer caused by algae. A biologist is regularly employed by the city whose duty it is to make regular tests and count of the number of different types of algae occurring in the lake and when the numbers are increasing to such proportions as to be objectionable the northerly third of the lake is treated with copper sulphate. The usual dose is about three tons and of late is applied twice per year.

PERSONNEL

The water supply is a Division under the Department of Engineering. All work in the division is in charge of a Division Engineer. Wm. W. Cronin is acting City Engineer, E. P. Stewart is Division Engineer and the writer is Consulting Engineer to the Division. The reading of meters, billing and collecting of water rents is done by the City Treasurer.

(Presented before the New York Section meeting, April 8, 1932.)

SUPPLYING SUBURBAN SYRACUSE

By A. A. Korves

(*Syracuse, New York*)

The Syracuse Suburban Plant of the New York Water Service Corporation, which supplies water and fire protection to the industries and communities suburban to the City of Syracuse, was incorporated on April 11, 1907 as the Onondaga County Suburban Water Company. On September 11 of the same year the name was changed to Syracuse Suburban Water Company, to define more clearly the location and territory to be served by this Company. When the system was acquired in January, 1927, by the New York Water Service Corporation, the name was changed to the Onondaga Water Service Corporation, remaining so until January, 1930, when it was merged with the New York Water Service Corporation and became known as the Syracuse Suburban Plant of the New York Water Service Corporation, under which name it is now known.

Under Chapter 371 of the laws of the State of New York of 1907, permission was granted to the Onondaga County Suburban Water Company to impound additional water in Otisco Lake, and to use the water so impounded.

Otisco Lake lies about 14 miles southwest of the City of Syracuse and about 4 miles east of Skaneateles Lake, which is the source of the supply to the City of Syracuse. In 1868 the State of New York built a dam near the site of the existing dam and thereby raised the lake level 10 feet. Their purpose in doing this was to supply additional storage and to use the water as a feeder to the Jordan level of the Erie Canal.

In 1907, pursuant to the act granting them permission to do so, the Water Company constructed a new dam about 20 feet downstream from the existing State dam, and raised the spillway elevation of Otisco Lake an additional 4 feet, thereby impounding an additional 3 billion gallons of water. In order to do this it was necessary to acquire considerable land and flood rights around the entire edge of the lake, to relocate and construct new highways around the lake,

and to satisfy claims for riparian damages by a large number of mill owners along Nine Mile Creek, the outlet from Otisco Lake.

DAM AND APPURTENANT STRUCTURES

The new dam consisted of a masonry gravity spillway section 55½ feet long adjacent to a masonry section in which are located three 48-inch square gates and the gate operating mechanism and platform. This masonry portion is flanked on either side by earthen embankments. In order to obtain a satisfactory foundation it was necessary to drive piles on about 3 foot centers through the quicksand and to cover this area with a floor of 10 by 10-inch timbers. Piles were also driven along the downstream side of the dam to prevent undertow and a row of interlocking steel sheet piling was driven on the upstream side, across the entire length of the dam. The top of the steel sheet piling was embedded in concrete and joined tightly to the grillage floor of the dam.

A 24-inch cast iron intake pipe was laid through the earthen embankment of the dam and for a distance of about 6,000 feet into the lake, to the intake crib. This location for the intake crib was decided upon after a careful study of the qualities of water found at different points of the lake had been made.

The intake crib consists of 12-inch by 12-inch timbers securely bolted together and the top of the crib is covered by a wooden grid made up of 2-inch by 10-inch plank on edge spaced 1 inch apart all securely bolted to the crib. The intake pipe at this point is 28 feet below the spillway elevation.

Just downstream from the dam is a masonry gate house in which are located the operating valves, venturi meter register, chlorinators and screen pots. From this a 24-inch C.I. pipe was laid for about 1½ miles at which point it reduces to 20-inch and continues for about 12 miles through the towns of Marcellus and Camillus to Fairmount Reservoir.

SUPPLY LINES

The spillway elevation of Otisco Lake is 786.6 and that of Fairmount Reservoir is 609, and the original system was designed for a capacity of 5 m.g.d.; however, as the territory and the demand on our system grew, this line became inadequate, and in 1927 about 10 miles of 24-inch C.I. pipe was laid parallel and cross-connected to the existing 20- and 24-inch line. This line started at a point about 3,000 feet

below the dam, because between that point and the dam it would have been necessary to lay the line in deep, wet cuts in order to be below the hydraulic grade line. As it was desired to decrease the friction loss by adding as much new pipe line as the appropriation would allow it was decided to do this work at points where construction would be comparatively easy and consequently less costly.

This enabled us to increase our draft from the lake to 8 m.g.d. with lake level at spillway elevation. The pipe lines for a distance of nearly 6 miles below the dam are very close to the hydraulic grade line, when the lake is at spillway elevation, so that with the lake drawn down 6 or 7 feet the hydraulic grade line falls below the top of our pipe lines with the result that the capacity of the pipe line is appreciably decreased, due to the accumulation of air in the summits. This condition was partly eliminated by installing automatic air valves at the summits of the pipe line and ejecting the accumulated air by raising the hydraulic grade line for short periods each day. This was done by partially closing a valve at the reservoir and the pipe line would then act as a siphon for some time.

At this time a study based on probable future demands was being made and it was decided to construct a booster pumping station near the dam. The other alternative was to lay a new intake pipe into the lake, and since this was a very expensive project, it was discarded in favor of a booster station.

With the pump in operation the grade line is depressed at the suction end of the pump and the capacity of the intake line is thereby increased. At the same time the grade line is raised on the discharge side of the pump so that with the pump operating we can draw from the lake at the rate of 10 m.g.d., with the lake drawn down to its maximum amount.

The demand on our system is at its peak during the winter months due to the increased draft by the New York Central Railroad during the cold and stormy weather, which may vary as much as 2 m.g.d. from their yearly average. At the same time when we have our maximum demand, the lake is at its lowest and pumping is necessary.

It is also intended to add additional pipe lines, filling in the gaps existing between the lake and the reservoir at such times when the cost of operating the booster station will balance the carrying charges of the additional pipe line. In this way we will defer the installation of an intake line for some time to come.

All of the water used, with the exception of the consumption west

of Fairmount reservoir passes through the reservoir, which is at elevation 609. This reservoir is circular in plan and has a capacity of about 5,000,000 gallons and consists of earthen embankments having its inner slopes lined with concrete and the outer slopes sodded. At the reservoir a circular gate house was constructed in which are located the operating valves and screen-pots on the outlet from the reservoir. From the reservoir, we have about 2 miles of 24-inch C.I. pipe, 2½ miles of 20-, then 16-inch pipe for a distance of about 10 miles, and 2 miles of 12-inch pipe to the extreme easterly end of our system at Minoa.

In 1927 this line was also paralleled in part with about 4 miles of 24-inch pipe in order to reduce friction losses, and a 4 m.g.d. booster pump installed at the eastern extremity of the new construction in order to take care of any peak demands which may arise east of that point.

AREA SERVED

This system supplies water to the Villages of Solvay, Liverpool, Cicero and Minoa, at a wholesale rate, and also to 7 water districts. Solvay Village in turn re-sells the water to various other water districts. We also operate the systems in the Villages of Camillus and North Syracuse, and in the territory lying north of the City line to the Village of North Syracuse, and in a section just northeast of the City, known as the Lyncourt Fire District. We sell water wholesale to the Solvay Process Company, to the New York Central Railroad Company at various points along their right of way and to numerous smaller industries along our transmission system.

We also supplied water to the Village of Eastwood until that Village was annexed to the City of Syracuse in 1926.

Under normal times the industrial demand on our system greatly exceeds the domestic demand, with a peak demand in the winter months. In order to level off these peaks it has been desirable to increase our domestic load and since the acquisition by the New York Water Service Corporation some progress has been made toward this end, as we have added practically all our domestic demand, exclusive of the Villages of Camillus and Solvay.

The territory supplied by our system is growing rapidly and we feel that the demands on our system will increase steadily in the years to come.

(Presented before the New York Section meeting, April 8, 1932.)

PROGRESS REPORT OF THE BOILER FEED WATER STUDIES COMMITTEE, YEAR 1932

The activity of the Boiler Feed Water Studies Committee during the past year, has been devoted primarily to the work at Ohio State University and at the University of Michigan, where research fellowships were established during 1931. The fellowship in the Department of Engineering Research at the University of Michigan was undertaken to study methods for boiler water analyses, for the purpose of securing accurate data necessary for standardization of analytical procedures. Two thousand dollars were appropriated for the period from July 15, 1931 to July 15, 1932. The Boiler Feed Water Studies Committee has authorized the continuation of this work for the Academic year of 1932 and 1933.

A progress report on "The Determination of Carbonates, Hydroxides and Phosphates in Boiler Waters" was released and published November 30, 1931 in *Mechanical Engineering*. Reports on the determination of Phosphates and Hydroxides in boiler waters were issued in January and February of this year. Owing to a lack of funds, copies of these reports were limited to Committee members, to those contributing to the research fund and to sponsor societies, with permission for republication as desired. There are a limited number of some of these reports still available and copies may be obtained from Mr. C. B. LePage of The American Society of Mechanical Engineers, New York City.

The Committee will shortly release a progress report upon the determination of sulphates. Further work on the determination of dissolved oxygen present in waters in small quantities will be undertaken, since inaccuracies are apparent in the recognized method now in use. It is planned to release the tentative standard method in sufficient time prior to the summer meeting of the American Society of Mechanical Engineers, so that the recommended procedure may be discussed at the Chicago meeting in June 1933.

The critical studies of analytical methods as carried on under the University of Michigan fellowship have clearly indicated that our present standards are wholly inadequate, and the continuation of

this form of research is worth while to meet the exacting conditions of feedwater treatment for high pressure steam station practice. This research committee is working in close coöperation with the Committee D-19 of the American Society for Testing Materials which was formed recently for the standardization of water analysis for industrial uses. Mr. C. H. Fellows has served as the Sub-committee chairman during the past year and much credit is due him for the development of analytical procedures which have so far been recommended.

The Sub-Committee on Priming and Foaming of Boiler Waters has continued the research work under the direction of Professor C. W. Foulk at Ohio State University. During Professor Foulk's extended absence from this country, the studies were directed by Mr. S. F. Whirl, acting as research assistant. This fellowship was inaugurated in April, 1931 and will continue to January 1, 1933. The Feed Water Committee's appropriation to date for this study has been $2380. The first progress report by this Committee was published in *Mechanical Engineering*, November 30, 1931 and a large number of reprints were distributed to the engineering profession. A limited number of reprints of this report are still available for distribution. A subsequent report of this research study will be released at a later date.

Tentative arrangements have been completed to conduct coöperative research between the Bureau of Mines and the Boiler Feed Water Studies Committee. The research will be devoted to a study of solubility equilibria of sodium sulphate in concentrated boiler water salines. The investigation will be made at the New Brunswick station of the Bureau of Mines and will be directed by Dr. E. P. Partridge. The estimated budget for the proposed program is $7500 a year for two years. The Committee, to direct this work will replace Committee number six which was set up originally to study the phenomenon of embrittlement of boiler steel. Mr. J. H. Walker will serve as Chairman of the new Committee and Mr. T. E. Purcell, Vice Chairman. Other members of this Committee are Messrs. Alex D. Bailey, R. E. Hall, E. B. Powell and J. B. Romer.

Financial assistance to carry out this work, is now being solicited and a number of Companies have already contributed to this special fund. The Bureau of Mines is to supervise the investigation without charge, supply the services of such investigators as it can assign from its force and make available equipment, office and laboratory

space as may be needed. The Committee plans to start active work on this problem shortly after the first of the year or as soon thereafter as the necessary funds are available. The financing of this study is independent of the general research fund for carrying the fellowships at Ohio State University and the University of Michigan.

It has been possible to continue the two research fellowships, now in progress, only by the generous contribution of $3000 from the Engineering Foundation, since no additional funds were contributed this year from other sources. It must be apparent to all responsible for the operation of steam boilers in modern high pressure stations, that considerable research work is still required to insure sufficient knowledge for adequate and economical control of such stations. To continue this important work will require additional financial support. If such assistance is not received, the research now in progress must be terminated before the programs, as originally outlined, have been completed.

By agreement with Rear Admiral Robinson, Director of Engineering of the U. S. Navy Department, the director of the U. S. Naval Experiment Station has been appointed as a member of the Executive Committee. The present incumbent in charge of the engineering at the Annapolis Station is Captain H. R. Greenlee. Extensive research on boiler feedwater conditioning is in progress at the Naval Experiment Station and your Chairman has conferred frequently with the director and his assistant, Lieutenant Commander Solberg, on such phases of this work which were of interest to this Committee, but which was not considered confidential by the Navy Department.

S. T. POWELL,
Chairman.

SOCIETY AFFAIRS

THE MINNESOTA SECTION

The twenty-second annual meeting was called to order on September 15, 1932, at 10:00 A.M. in the Blue Room, Breen Hotel, St. Cloud; Ole Forsberg, Chairman, presiding. Honorable Phil Collignon, Mayor of St. Cloud, gave the address of welcome. Response was made by the very able Ole Forsberg, Chairman.

A symposium on Ammonia-Chlorine Process was led by Ole Forsberg, Sanitary Engineer, Oliver Iron Mining Company, Hibbing, Minnesota. Following this a paper on Ammonia-Chlorine Process was delivered by C. L. Ehrhart, Superintendent of Water Department, St. Cloud. Others who participated in the discussion were Messrs. Frank Raab, Bacteriologist, Minneapolis Water Department, Ross A. Thuma, Bacteriologist and Chemist, St. Paul Water Department. This concluded the morning program.

The afternoon session began with a talk on "The History of Manganese it Ground Waters and the Methods Tried for its Removal" by Carl Zapffe, Manager Iron Ore Properties, Northern Pacific Railway Company, Brainerd, Minnesota. To the speaker's knowledge and others who were present at the meeting, there never yet has been published any data on this subject. The talk aroused much interest especially with those who are bothered with manganese and iron. Following this we took an educational tour going through the Granite Works, watching a demonstration of "Measuring Fire Flows" by Sanford Herberg, Engineer General Inspection Bureau, Fire Underwriters, Minneapolis, and a trip through the St. Cloud Filtration Plant.

The meeting adjourned until 7 P.M. at which time dinner and entertainment was had. During the dinner we were entertained by the Kiddies Revue from Mrs. Anderson's Dancing School. Following the dinner an address was given by G. W. Friedrich, State Teachers College, St. Cloud, on "Algae in Swamp Waters." After this the meeting was at recess until 9:15 Friday morning, September 16, 1932.

Mr. Forsberg appointed the following on the Nominating Com-

mittee: Messrs. Seibert, Thuma, and James; on the Auditing Committee, Messrs. Crowley, Raab and Campbell.

Mr. B. C. Little, National Secretary A. W. W. A., Rochester, New York, gave a very nice talk on his recent European trip and mentioned having met Sir Alexander Houston of London who is a member of the A. W. W. A. and depicted a few of Alexander's reports. The gist of the reports explained ocean evaporation, clouds, rain, etc., beauty of rivers and waterways, cleverly included pollution hazards and preventions in this description. Sir Alexander is very proud of London's water works and described a trip up the Thames River and how they protect it from pollution.

Mr. Foster delivered his paper on "Construction and Value of Softening Plant to Municipality." Mr. E. M. Grime, Engineer of Water Service, Northern Pacific Railway, St. Paul, and Mr. B. W. DeGeer, Water Service Engineer, Great Northern Railway, St. Paul, discussed Mr. Foster's paper and also told of the necessity of soft water for locomotive boilers. They mentioned that soft water created 25 percent saving annually. Following this a short discussion took place led by Ole Forsberg regarding soft water for laundries and reaction of public regarding increased cost. This proved to be a live wire subject. Public complains of tastes and imagines iodine and other medicines are added. Messrs. Thompson, Zapffe, and Druar suggested soft water and say nothing to public.

Mr. G. E. Basom, Superintendent of the Water and Light Commission, Fairmont, who had the last paper on the morning meeting, was not present, so a general discussion took place led by Ole Forsberg. Mr. Druar contributed greatly by relating his experience with leaking mains. Mr. Kelly of Duluth compared geophone and pitometer for testing leaks and said all of these instruments are tricky. Mr. Grove of Stillwater stated that he believed the small city had the advantage over the large in finding leaks. Mr. Tarbell believes it advisable to hire a "leak specialist" for survey periodically, with ultimate great saving.

Meeting was adjourned at 11:50 after Ole Forsberg announced that luncheon in main dining room was free. Luncheon was served at 12:30 and minutes read. At 1:00 P.M. the report from the Finance Committee was read. Mr. Forsberg mentioned Mr. Howe's death and stated that a motion of condolence was passed.

Mr. Ole Forsberg read letter from Mr. Hooper of Winnipeg and asked for suggestions. Mr. Thompson suggested we consider their

offer before jumping into it. Mr. Ehrhart cited Iowa's joining with Missouri Valley Section and how they faded from recognition which they are sorry for—amendment was that the committee consider this and report at a later date. The Nominating Committee suggested Druar—Chairman; Thompson—Vice-Chairman, and C. C. Wilbur Trustee to succeed Mr. Thompson. Mr. Raab motioned that Mr. Forsberg be elected representative from this section to attend the business meeting of the national association. The nominations were passed by acclamation. Finch was appointed by the Board of Directors to continue as secretary and treasurer.

At this point Mr. Forsberg turned the meeting over to Mr. Druar. He suggested we get new members. At this point letters were read from the Minneapolis Civic and Commerce Association and Mayor Anderson extending an invitation to the Section to hold its 1933 meeting in Minneapolis. Mr. Druar asked for other bids. None were presented. Mr. Forsberg motioned that it be held at Minneapolis. It was seconded and unanimously accepted. Mr. Forsberg suggested a winter meeting up on the range. Mr. Druar asked chair to accept suggestion.

Following this Mr. Druar gave his talk on "Value of Water Works to Small Community." Some very interesting information developed from the round table discussion.

In the absence of Mr. H. O. Williams, Secretary and Treasurer of Edward E. Johnson Co., St. Paul, John Druar read his paper on "True Significance of Draw Downs in Wells."

The final count showed a registration of 76 which was the same as the previous year.

R. M. FINCH,
Secretary and Treasurer.

THE ROCKY MOUNTAIN SECTION

Twenty seven Section members and 67 guests attended the sixth annual meeting of the Rocky Mountain Section, held at the Cosmopolitan Hotel, Denver, Colorado, October 24, 25, 26, 1932. Despite the depression this was the best annual meeting ever held by the Rocky Mountain Section, measured both in the enthusiasm of those in attendance, the quality of the papers presented, the interest in the discussions, and the quality of exhibits.

As in the case of the Fifth annual meeting, a two-day water works college was held in conjunction with the meeting this year through

the coöperation of the Extension Division of the University of Colorado. Of particular interest and value was the laboratory session on the afternoon of the second day, held in the bacteriological laboratory of the Medical School of the State University where demonstrations of microscopical, bacteriological and chemical tests of water were made.

The program was as follows:

Greetings from the A. W. W. A., Geo. W. Pracy, President, A. W. W. A., San Francisco, Calif.

Rate Structures and Fire Hydrant Rental, R. E. McDonnell, Consulting Engineer, Kansas City, Mo.

Algae Control, Paul S. Fox, Prof. of Sanitary Engineering, U. of N. Mex. Albuquerque, N. Mex.

Some Operating Experiences with the Ammonia-Chlorine Process, C. R. Cederberg, Denver, Colorado.

Water Pumps and Pumping Problems, Louis R. Douglass, Consulting Engineer, Denver, Colorado.

Filter Sands, F. M. Veatch, Consulting Engineer, Kansas City, Mo.

Microscopical Examinations for Algae and Bacteria, Prof. Severance Burrage, University of Colorado Medical School, Denver, Colorado

Bacteriological Examinations for B. Coli., Prof. Ivan C. Hall, University of Colorado Medical School, Denver, Colorado

Chemical Examinations for pH., Chlorine, Alkalinity, etc., Prof. Chas. F. Poe, University of Colorado, Chemistry Dep't, Boulder, Colorado

Application of Activated Carbon in Water Purification, Fred E. Stuart, Industrial Chemical Sales Co., New York, and George Roeschlaub, Denver Fire Clay Co., Denver

To What Extent Should Water Bills be Rebated,

Should City Water Works Be Under a Board of Public Works, G. C. Culberson, Manager, City Water Works, Raton, New Mexico

Liability of Municipalities in Water Borne Disease, B. V. Howe, State Sanitary Engineer, Denver, Colorado.

Loans to Municipalities and Private Water Companies by the Reconstruction

Finance Corporation for Construction of Self-liquidating Public Works, D. E. Kepner, Denver, Colorado

(Trip to Beet Sugar Factory of the Great Western Sugar Co., Brighton, Colo.)

At the business session the officers for the ensuing year were elected and new By Laws were adopted, superseding the Constitution of the Section which was adopted at its formation six years ago. The new officers are, Chairman, Dana E. Kepner, 226 Continental Oil Building, Denver, Colorado; Secretary-Treasurer, Benjamin V. Howe, 420 State Office Building, Denver, Colorado, Trustees, terms ending 1935, Paul S. Fox, State Bureau of Public Health, Santa Fe, N. Mex., and E. A. Bradner, Agua Pura Co., E. Las Vegas, N. Mex. Other Trustees, serving hold-over terms, are, C. A. Truman, Colorado Springs, Colo., F. E. Keenan, Gunnison, Colo., D. V. Bell, Rock Springs, Wyo., and E. C. Gwillim, Sheridan, Wyo. The Director of the A. W. W. A., representing the Rocky Mt. Section, is Mr. Burton Lowther, Denver, Colo.

DANA E. KEPNER,
Secretary-Treasurer.

THE MISSOURI VALLEY SECTION

The Eighteenth Annual Meeting of the Missouri Valley Section was called to order by Chairman H. L. Brown, City Manager, Salina, Kansas, in the Assembly Hall of the Hotel Martin in Sioux City, Iowa, at 11:25 A.M., Tuesday, October 25, 1932. There were 40 persons present. The Hon. W. D. Hayes, Mayor of Sioux City cordially welcomed the members of the Missouri Valley Section to Sioux City and expressed the hope that the meeting would be both pleasant and profitable. Chairman Brown responded to the address of welcome, expressing the appreciation of the Section in having this opportunity to visit Sioux City.

The appointment of the following committees was then announced:

Resolutions Committee: Chairman, J. W. McEvoy, Supt. of Water Works, Dubuque, Iowa; W. W. Towne, Director of Sanitation, State Board of Health, Waubay, South Dakota; W. J. Klevorn, Pittsburg Meter Co., Cedar Rapids, Iowa; C. A. Haskins, Consulting Engineer, Kansas City, Mo.; W. Scott Johnson, Chief Public Health Engineer, State Board of Health, Jefferson City, Mo.

Auditing Committee: H. V. Pedersen, General Manager and Superintendent of Water Works, Marshalltown, Iowa, and H. W. Badley, Superintendent of Water Works at Carroll, Iowa.

The Nominating Committee through its chairman, Mr. H. F. Blomquist, Superintendent of Water Works at Cedar Rapids, Iowa, reported progress and asked that their final report be received at the next session. This request was granted.

A round table discussion on the topic: "The Reconstruction Finance Corporation and Water Works" was opened by Mr. N. T. Veatch, Jr., Consulting Engineer of Kansas City, Mo.; Messrs. John W. Pray, Superintendent of Water Works at Fort Dodge, Iowa; Dr. Edward Bartow, Head of the Chemistry Department, University of Iowa, Iowa City, Iowa; John Fulkman, Consulting Engineer, Chicago; E. L. Waterman, Professor of Sanitary Engineering, University of Iowa, Iowa City, Iowa; J. W. McEvoy, W. W. Towne; H. F. Blomquist; H. V. Pedersen and Thomas Maloney, Water Works Trustee, Council Bluffs, Iowa, participated in the discussion. It was brought out that in most of the states represented the laws were such that a bond issue must be approved by the voters and doubt as to the possibility of securing this approval at this time was expressed. It was suggested that committees representing each state be appointed to secure information as to the procedure which must be followed in order to secure the aid of the Reconstruction Finance Corporation for water works improvements. Upon motion by Mr. Maloney, seconded by Mr. McEvoy and duly carried it was voted that the Chairman appoint such a Committee of Iowa members. The following committee was appointed: Chairman, Thomas Maloney, J. W. McEvoy and John W. Pray.

After several announcements by the Secretary the meeting was adjourned at 12:30 P.M.

The second session was called to order by Chairman Brown at 2:30 P.M., October 25, and the following papers were presented: "History of the Sioux City Water Works," Phil Carlin, Superitendent of Water Works, Sioux City, Iowa: "Rate Making," N. T. Veatch, Jr., Consulting Engineer, Black and Veatch, Kansas City, Mo.; "Studies in the formation of Floc Using Aluminum Sulfate," A. P. Black, Prof. of Agricultural Chemistry, University of Florida, Gainesville, Owen Rice, Fellow in Chemistry, University of Florida; Dr. E. Bartow, Professor of Chemistry and Chemical Engineering, University of Iowa, Iowa City; "Choosing a Water Works Superintendent," H. V. Pedersen, Superintendent and General Manager of Water Works, Marshalltown, Iowa; "Coagulation with Aluminum Sulphate," August A. Nolte and Warren A. Kramer.

Chairman H. F. Blomquist presented the following report of the Nominating Committee:

For Chairman: Joseph S. Nelson, Sioux Falls, S. Dak.

For Vice-Chairman: Leonard A. Day, Division Engineer St. Louis Water Works, St. Louis, Mo.

For Directors: Wm. M. Barr, Chemist, Union Pacific System, Omaha, Nebr.; Phil Carlin, Superintendent, Water Works, Sioux City, Iowa; W. W. Towne, Director, Division of Sanitation, State Board of Health, Waubay, South Dakota; W. Scott Johnson, Division of Sanitary Engineering, State Board of Health, Jefferson City, Missouri; Earnest Boyce, Chief Engineer, State Board of Health, Lawrence, Kansas.

Upon motion, duly seconded, it was voted that the report be received. (At the business meeting on Thursday, October 27, the men nominated by the Committee were elected officers of the Section for the ensuing year.)

The third session was called to order by Vice-Chairman Joseph S. Nelson at 2:25 P.M., Wednesday, October 26. The following papers were presented: "Water Cheaper than Dirt." C. A. Haskins, Consulting Engineer, Kansas City, Mo.; "The Use of Ammonia in Water Purification," Daniel Rupp, Superintendent of Filtration, Topeka, Kansas; "Railroad Water Supplies," C. R. Knowles, Superintendent of Water Service, Illinois Central System, Chicago; "Lime Slaking," E. E. Harper, Omega Machine Co., Kansas City, Mo. (read by the Secretary).

Following the reading of papers several questions from the Question Box were brought up for discussion.

"How are unpaid bills of unemployed handled?" In the discussion of this question it developed that various methods were used to handle the situation. Some departments referred the cases to the City Welfare Association for investigation and upon receiving reports indicating that the cases were worthy allowed the delinquents to work out the bills. Some cities have adopted public improvement programs to provide work for the unemployed. Most of the superintendents who discussed this question reported that the total of delinquent bills during the past year was small. It was apparent from the discussion that the matter of delinquent bills among the unemployed had not yet become a serious financial problem.

"When a discount is allowed on water bills if paid on or before a set date, what, if any, consideration is the customer given who

comes in 2, 7 or 10 days after the discount date has expired and asks that the discount be allowed?"

One superintendent reported that one day of grace was allowed in his department. All others adhered strictly to the discount date.

"When there has been a discussion on a water bill, discount, or any business pertaining to the department, between a customer and a clerk which results in the customer's not being satisfied and going over the clerk's head to one of the higher officers—should not the clerk be consulted by the officer before endeavoring to make a settlement?" It was unanimously agreed that the answer was "Yes."

"Which is most satisfactory, the small or large discount on water bills and why?" This question brought out a variety of answers, but the general opinion seemed to be that small discounts were more logical.

"Is it general practice to shut off the water in front of valves when replacing defective valve stems?" It was agreed that shutting off the water was a much safer procedure and this practice seemed to be generally followed.

The fourth session of the meeting was called to order by Chairman Brown at 9:20 A.M., Thursday, October 27. The following papers were presented: "Blood Worm Control in Open Reservoirs," Wm. T. Bailey, Chemist, City Water Works, Council Bluffs, Iowa; "Operation Experience at the Cedar Rapids Water Purification Plant," H. F. Blomquist, Superintendent of Water Works, Cedar Rapids, Iowa; "The Air Oxidation of Ferrous Sulfate," Jacob Cornog, Assistant Professor of Inorganic Chemistry, University of Iowa, Iowa City, and Albert Hershberger, Dupont Cellophane Co., Buffalo, N. Y. (read by title); "Water Softening Plants for Small Cities," H. R. Green, Consulting Engineer, Cedar Rapids, Iowa, (read by Secretary).

The annual business session of the Missouri Valley Section followed the reading of papers on Thursday morning. The Auditing Committee reported that the accounts of the Treasurer had been examined and found correct. It was moved, seconded and carried that the report be accepted.

The following report of the Resolutions Committee was formally accepted.

"WHEREAS, the Missouri Valley Section of the American Water Works Association in meeting at Sioux City, Iowa, October 25, 26, and 27, 1932 has

enjoyed both from a technical and a social standpoint a most profitable and enjoyable meeting.

"*We Therefore Resolve*, that this association expresses its sincere appreciation to Mayor W. D. Hayes, Commissioner Milton Perry Smith and Superintendent Phil Carlin and other officials and employees of the Sioux City Water Works Department for their splendid effort and invaluable assistance toward this most successful 18th annual meeting of the Missouri Valley Section.

"*That* we express our thanks to those responsible for the enjoyable tour of the waterworks' and city properties of Sioux City, and for the delightful and enjoyable luncheon and entertainment so graciously provided for the members and lady guests by the Sioux City Waterworks Department.

"*That* we offer our appreciation for the untiring and unceasing efforts of the officials of the Missouri Valley Section of the American Water Works Association who are largely responsible for the success of the Association and this meeting; and to those members presenting papers at the sessions.

"*That* the Sioux City Journal and the Sioux City Chamber of Commerce for its invaluable assistance, and to the management of the Martin Hotel for its excellent and courteous service.

"*Be It Further Resolved* that this Association goes on record as expressing its most heartfelt appreciation to Mr. Carlin, not only for this assistance toward the success of this annual meeting, but for his many years of unfailing support of the association and the waterworks profession, enhanced by his sterling qualities of character, high esteem and reputation both among the profession and the public which he has so faithfully served; and that this association strongly urges that his excellent paper on the "History of the Sioux City Water Works" be published in full in the local press and the Journal of the Association.

W. J. Klevorn
W. Scott Johnson
C. A. Haskins
W. W. Towne
J. W. McEvoy, *Chm.*"

Upon motion by Mr. Blomquist, seconded by Mr. J. S. Nelson, it was voted that the Secretary be instructed to cast a unanimous ballot for the men nominated by the Nominating Committee for officers of the Section for the ensuing year. The Secretary cast the ballot and the nominees were declared elected.

Under head of new business the question was raised as to whether a two day instead of a three day annual meeting was desirable. After discussion it was voted that the Secretary be instructed to canvass the membership by ballot to ascertain their opinions.

Cordial invitations to hold the next annual meeting in their respective cities were received from officials of Fort Dodge, Iowa, Excelsior Springs, Mo.; Omaha, Nebr., and St. Louis. It was

voted that the choice of the next meeting place be left to the Executive Committee.

The Secretary presented a report showing changes in the membership since the last annual meeting.

Mr. Frank Lawlor, Superintendent of Water Works at Burlington, Iowa moved that a vote of thanks be extended to the Officers of the Section for their work during the past year. The motion was seconded by Mr. Pray and duly carried.

The Eighteenth Annual Meeting of the Missouri Valley Section was declared adjourned at 12:10 P.M., October 27, 1932.

EARLE L. WATERMAN,
Secretary.

ABSTRACTS OF WATER WORKS LITERATURE[1]

FRANK HANNAN

Key: American Journal of Public Health, **12:** 1, 16, January, 1922. The figure 12 refers to the volume, 1 to the number of the issue, and 16 to the page of the Journal.

Constructing the 35-Mile New Madrid Floodway Levee. T. T. KNAPPEN. Eng. News-Rec., **106:** 636-41, April 16, 1931. Detailed description of construction of 35-mile floodway levee of Mississippi flood protection works in Missouri containing over 11,000,000 yards of fill.—*R. E. Thompson.*

Calculating Floodflow Over an Embankment. ALBERT S. FRY and G. H. HILKOX. Eng. News-Rec., **106:** 557–8, April 2, 1931. In connection with raising of railroad tracks following flood of 1927 on White River in Arkansas it was necessary to calculate flow of flood water over railroad embankment. In first estimate, the formula for broadcrested weir, $Q = CLH^{\frac{3}{2}}$, was employed, using low value, $C = 2.64$, for coefficient of discharge, owing to irregularities in embankment. Subsequent experiments at University of Iowa (by D. L. YARNELL and F. A. NAGLER), published in Public Roads, April, 1930, confirmed use of broadcrested weir formula, but indicated use of values for C ranging from 0.70 to 3.27 for conditions encountered, value depending on degree of submergence. Regarding flow through pile trestles, records were available for lesser floods than that of 1927, with observed differences in water level between upstream and downstream sides of track. From these a relation between velocity, V, and head loss, H, was determined. For single- and double-tract trestles, values for H, under existing conditions were given by $H = 0.08V^2$ and $H = 0.15V^2$, respectively. Formula is not believed to be of type generally applicable, as losses should be less under more ideal flow conditions. [Correction in Eng. News-Rec., **106:** 729, April 30, 1931.—ABSTR.] —*R. E. Thompson.*

Phoenix, Arizona, Water System Improvements. Eng. News-Rec., **106:** 581, April 2, 1931. Improvements to water system, contract for which was let December 6, 1930, include 31½ miles 24- to 54-inch supply line to replace redwood pipe line, 20-million gallon circular concrete-lined reservoir, and 8 miles 6- to 12-inch distribution mains. Unit prices bid on welded steel and centrifugally-cast concrete pipe are tabulated.—*R. E. Thompson.*

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[1] Vacancies on the abstracting staff occur from time to time. Members desirous of coöperating in this work are earnestly requested to communicate with the chief abstractor, Frank Hannan, 285 Willow Avenue, Toronto 8, Ontario, Canada.

Water Works Practice Abroad. Eng. News-Rec., **106**: 480–1, March 19, 1931. Outstanding features noted in review of water supply engineering in 1930 published in Engineer (London) of January 9, 1931, are given. Two galleries, one, or both, of which had been used since 1832 in Perth, Scotland, were replaced by single filter gallery. Under parliamentary legislation of 1930, no large reservoir (over 6 million gallons, U. S.) can be built in England or Scotland unless "a qualified civil engineer is engaged to design and supervise construction. At Belfast, a cutoff trench with maximum depth of 212 feet was completed, the concrete wall poured, and embankment to form Silent Valley reservoir was started during year. Total of 2833 acres of land immediately surrounding Lake Vyrnwy, main source of supply of Liverpool, had been forested at close of 1930. Most of major water supply conduits completed or under construction during year were of steel. In number, centrifugal pumps are far in lead in new installations reported, while for power, oil engines lead in number. Apparatus for treating 57.6 million gallons of water per day with ammonia and chlorine was provided at Kempton Park double filtration plant on Thames. (London Metropolitan District.) The Board also installed an ammonia plant at Barnes in connection with new chlorine apparatus.—*R. E. Thompson.*

Water and Sewage Problems of Four Illinois Cities. Eng. News-Rec., **106**: 647–50, April 16, 1931. Water supply of Champaign and Urbana Water Company, derived from moderately deep wells, contains considerable iron. Water is initially aërated by free fall of several feet through air as it enters sedimentation basin, inlet consisting of horizontal 24-inch cast iron pipe perforated on upper side. The water falls into series of shallow staggered overflow troughs, from last of which it drops into basin. Secondary aëration, prior to rapid sand filtration, is effected by arrangement of filter influent piping by means of which water is again allowed a free drop through air. Pipe connecting with sedimentation basin is brought up vertically through center of sand bed and terminates in open end a few feet lower than basin water level and 3 or 4 feet above level of water in filter. Arrangement was originally designed to assure constant rate of flow to filter. Water has been treated in various ways to overcome troubles due to crenothrix. Present procedure is to apply chlorine at two points, to suction of raw water pump and to effluent from filters. About 12 pounds of chlorine is applied per million gallons, dosage being proportioned to maintain residual of 0.2 p.p.m. in effluent. Filter wash water is heavily chlorinated. Dosage is not known, but is very high, free chlorine escaping into filter house. Some years ago an auxiliary grid of wash water piping, jets from which agitated surface of sand during washing, was experimented with but abandoned. Decatur, Illinois, derives its supply from north fork of Sangamon River. Treatment consists of application of lime and alum as softening and coagulating chemicals, sedimentation, and filtration, with recarbonation as intermediate step. Impounding reservoir, 12 miles long and ½ mile wide, was created on river to provide for periods of low flow. Bathing and boating are permitted, no great concern being felt by authorities regarding pollution from this source owing to great size of lake in relation to possible concentration of population. The sewage plant effluent discharges into San-

gamon River. For several months during past summer, water demand exceeded river flow. With no water overflowing the dam, the entire river, in effect, was diverted through city, routed to sewage treatment plant, and then returned to riverbed without dilution. Ordinarily, this condition obtains only during a week or so each summer. About 55 miles below Decatur, on same river, is the Springfield, Illinois, water works. Fortunately, however, natural purification, in addition to sewage treatment at Decatur and water purification at Springfield, effectively safeguards health of the community. Biochemical oxygen demand of river water is about 2.5 p.p.m. above Decatur dam, increases to from 150 to 250 p.p.m. after passing through water system to sewage works, decreases to from 5 to 10 p.p.m. after treatment, and is 2.5. to 3.0 p.p.m. at Springfield intake. Maximum pollution at Springfield occurs during medium river stages. At times of low flow natural purification proceeds as above indicated; as flow increases, time of travel between the two cities is reduced and decreased purification effected is not sufficiently compensated for by increased dilution, pollution therefore increasing until stage is reached at which dilution becomes predominant factor. Purification process at Springfield consists of lime softening, sedimentation, and rapid sand filtration. The lime sludge is much sought after by local farmers. Sand grains become materially incrusted with calcium carbonate, but it is considered more economical to replace sand when necessary than to employ recarbonation. Pre-ammoniation has been successfully practised for some time for eliminating taste and odors.—*R. E. Thompson.*

Status of Water Development in the Eleven Western States. A Symposium. Eng. News-Rec., **106**: 428–31, March 12, 1931. **Washington: Low Rainfall Stimulates Irrigation West of the Cascades.** CHARLES J. BARTHOLET. 428. Brief data on water development in Washington. Present water code, passed in 1917, appears entirely adequate. Although riparian rights are not referred to specifically in code, they are recognized by inference. There is tendency, however, for courts to modify riparian doctrine and render it of little value unless right has been exercised. In 90 percent of adjudications water rights are based on appropriation doctrine, and decisions are not appealed. **Nevada: Appropriations are Mainly for Stock Watering on the Public Domain.** GEORGE W. MALONE. 428. Brief data on water appropriation in Nevada. Unappropriated supplies consist only of flood and underground waters. Based on right of appropriation and beneficial use, present state water code is considered adequate. **California: Plans Completed for First Units of Comprehensive Program.** EDWARD HYATT. 428–9. Following decade of intensive study to establish program for most practicable utilization of state's water resources, plan for initial developments has been formed which will be recommended to legislature. Economically, these first units, costing $375,000,000, are believed justified by benefits which will result, provided costs are not assessed entirely against areas to be served, but are in part distributed among other benefited interests, including utilities, urban communities, and state and federal governments. Half a century of study of water problem underlies the recommendations. Summer flows in major streams are almost completely appropriated and future developments will require storage.

Further, certain local areas have their local water supply fully developed and in use. Seasonal and geographical distribution of precipitation in state is extremely unequal. Precipitation occurs almost entirely during short winter period, and 75 percent of rainfall returns to ocean within 45 days unless diverted, or stored. Geographically, 75 percent of natural water occurs within northerly third of state's area, while 75 percent of demand is in other two-thirds. Thus full utilization of available water supplies will involve transportation of surplus from northern sections to remote areas in south. Complicating water development, courts have declared that riparian owners are entitled to restrain diversion of any waters that may be beneficial to their land, without any limitation as to measure of reasonableness in their use or method of use. There is need for speedy and adequate tribunal which will determine value of surplus waters necessary for exportation to areas of deficient natural supply. **Idaho: New Areas Must Wait Until Present Acreage Has Assured Supply.** GEORGE N. CARTER. 429. Brief data on status of water development in Idaho. Present water code, based on appropriated rights, is considered adequate for present needs, with possible minor changes to facilitate administration. **Oregon: Hydro-Electric Development a Much-Discussed Question.** CHARLES E. STRICKLIN. 429. Brief data on status of water development in Oregon. State water code, enacted in 1909, is considered satisfactory. It has been construed by courts to abrogate entirely the riparian theory of water rights. **Montana: Plans Under Way for Economic Water-Development Program.** J. S. JAMES. 430. As little unappropriated streamflow is left, source of future supplies must be floodflows conserved by storage reservoirs. Present water code, based on appropriator's right, is not considered adequate, and efforts are being made to improve it. **Colorado: Unappropriated Water in State Confined to Colorado River System.** M. C. HINDERLIDER. 430. Only unappropriated water in state originates in Colorado River and its tributaries. Present laws governing use of water, based on doctrine of priority of use, are considered fully adequate by both users and administration. Comprehensive study of state water resources has been under way for 2 years. **Utah: Irrigation Expansion Slows Up and State's Coal is Studied for Power.** GEORGE M. BACON. 430. Brief data on status of water development in Utah. Present water code, which recognizes only rights acquired by appropriation, is believed to be wholly adequate for present needs, except in application to underground supplies that do not flow in known or defined channels. **Wyoming: Future Water Developments Will be Made in Large Unites.** JOHN A. WHITING. 430. Earlier water development projects utilized smaller and more accessible supplies; future development will necessarily be in larger units and at increased unit cost. Water code, based exclusively on doctrine of appropriation, is considered adequate for present needs except for minor changes, particularly as regards requirements of administration. About 30 per cent of available water is now applied to beneficial use. **New Mexico: Future Developments Will Require Extensive Storage.** HERBERT W. YEO. 431. Unappropriated waters of state, confined principally to San Juan and Canadian Rivers, are largely flood waters and can be utilized only in connection with extensive storage facilities. Water code, based exclusively on doctrine of appropriation, is not adequate. New code

will probably be submitted to legislature this year. **Arizona: Irrigated Acreage is Enlarged Despite Subnormal Rainfall.** FRANK P. TROTT. 431. Brief data on status of development of water in Arizona. Water code, based on right of appropriation, is considered adequate, with possible minor changes to give more specific authority to enforcement of code. No definite comprehensive program for studying development of state's water resources as a whole has ever been undertaken.—*R. E. Thompson.*

Water Supply Conditions in Drought Regions. Eng. News-Rec., **106**: 452-4, March 12, 1931. After 11 months of continuous severe rainfall deficiency streams had dried up, wells and springs had ceased to flow, and empty reservoirs and part-time operated water systems dotted state of Kentucky. There was no relief until early weeks of February when there were light rains. Rainfall was well above normal in January, 1930, and normal in February, 1930, but due to deficiency during remaining months, year's total was only 27.55 inches, or 61 percent of normal value. Prior to 1930, driest year on record was 1894, with 34.81 inches. During last 10 months of 1930, rainfall was only 50 per cent of normal. Many streams, including two of larger ones, became dry during year. Recourse to water transportation in tank cars was in several places necessary. At Shelbyville, 16 cars of 10,000-gallons capacity were received every day for 7 months from Louisville and, in addition, pumps were only operated for 12 hours each day. Richmond, also, had to transport water by railroad. Lexington brought in water from Kentucky River, 6½ miles away, through 20-inch pipe line (steel and cement-lined cast iron) which was begun in October and put in service in December, an emergency pumping station being constructed at river. Louisville, although blessed with ample supply, suffered from objectionable tastes resulting from low stage of Ohio River. Combination of unprecedented low discharge and canalization of river, now complete, has brought about entirely new biological conditions. The Ohio at Louisville now resembles a lake. Turbidity has decreased and algae have enormously increased. Heretofore plankton count of 1200 per cc. was maximum; during 1930, counts of 4000 to 5000 were not uncommon, creating taste problem. Maximum-hour pumping loads in Louisville increased greatly. Prior to 1930, ratio of maximum-hour to average-day demand varied between 1.79 and 1.97; while in 1930 this ratio attained value of 2.86. State Department of Health carried out extensive typhoid immunization program involving about 750,000 people. In spite of this, typhoid figures showed increase of 21 per cent over 1929. Widespread outbreak of acute intestinal disturbances occurred in January and February of this year in cities using Ohio River water. Although treated water in all cases had musty, decay-like taste, bacteriological examinations consistently failed to indicate presence of infection. Outbreak has not been explained, although in opinion of public health officers the water contained an intestinal irritant, chemical in nature, resulting from decomposition of organic wastes present in river water—*R. E. Thompson.*

Streamflow Differences in 1930 Drought. ROBERT FOLLANSBEE. Eng. News-Rec., **106**: 473, March 19, 1931. Tabulated data are given regarding precipitation and discharge of streams during 1929 and 1930 in adjacent states

of South Dakota and Nebraska, showing in striking manner the lack of general relationship between precipitation and runoff. Many years ago, HENRY GANNETT made study of relationship between precipitation and discharge in United States (unpublished report, United States Geological Survey) and came to conclusion that when former is less than 20 inches there is no relationship between the two, the proportion of discharge depending very largely on intensity of precipitation. In addition, stage of ground water is important factor. Data given conform to this theory.—*R. E. Thompson.*

Field Notes on Water Supply Conditions in Drought Regions. Eng. News-Rec., **106**: 565–7, April 2, 1931. Since December, 1929, when precipitation in West Virginia was only 74 percent of normal, every month to present time has shown rainfall deficiency. During year 1930 rainfall was only 59 per cent of normal value. In December, 1930, light snows and rains brought precipitation up to 80 per cent of average, the nearest approach to normal during year. Precipitation in January, 1931, however, was down again to only 35 per cent, and February also shows marked deficiency. Prevalence of plants drawing directly from flowing streams makes for immediate response to unprecedented rainfall and runoff conditions. Impounding reservoirs are uncommon in the state. Flow in many streams decreased to zero and until some relief occurred following light snows and rains in December numerous plants were maintaining service by utilizing drainage from abandoned coal mines, pumping from distant watersheds through emergency pipe lines, and transporting water in tank cars from more fortunate communities. Even in cities having adequate supplies difficulties were experienced due to increased mineral content and objectionable tastes resulting from low stream flows. Ground water supplies held up well, but are now showing evidences of approaching depletion. Conditions in various communities are described. Water supply of Charleston is drawn from Elk River, 1¼ miles above its junction with the Kanawha. Sewage of city is discharged into river below the confluence and, in addition, municipal incinerator has been discharging 200 tons of household refuse and spoiled produce from wholesale houses for more than a year. As river flow decreased during drought, effect of canalization works on the Kanawha was to create long pool in the two river beds extending beyond city. On July 24th, flow in the Elk had become less than draft of water works, and water from the Kanawha pool began to be drawn upstream, carrying with it its load of organic life. Dissolved oxygen content of raw water dropped to zero, the 37° count increased to between 50,000 and 100,000 per cc., and *B. coli* were present in 0.001 cc. Heavy growths of algae and protozoa had developed in pool and nauseating taste resulted. Prechlorination at rate of 4 p.p.m. reduced bacterial load, copper sulfate applied every other day to pool reduced micro-organic life, and aëration at inlet to sedimentation basin restored oxygen dissolved content to some extent. Notwithstanding superchlorination, ammoniation, and application of activated carbon, objectionable taste remained to certain extent. Aëration appeared to effect the greatest improvement. Filtration through bed of activated carbon was tried experimentally and seemed successful; but this treatment was not considered practicable as emergency measure. Taste persisted until December 20th, when flow was

re-established in Elk River. Emergency supplies were carefully supervised and extensive typhoid immunization program was carried out. Typhoid rate showed small increase, from 11.6 per 100,000 in 1929 to 12.6 in 1930.—*R. E. Thompson.*

Field Notes on Water Supply Conditions in the Drought Regions. Eng. News-Rec., **106**: 653–6, April 16, 1931. Of 244 communities in Virginia having public water supplies, 36 had to resort to emergency measures during drought. To date, rainfall deficiency has been recorded for 15 months. Dry period started in December, 1929, and extended throughout 1930. Although December, 1930, rainfall came within 2 percent of normal, total for year was but 60 percent of that which has been considered normal. January, 1931, precipitation was only 47 percent of normal. Public water supplies in southern Ohio also suffered serious depletion. During first 2 months of 1930 there was an excess of precipitation over Ohio as a whole, but every month since then has shown deficiency. Rainfall during 1930 was 27 inches, or 71 percent of normal value. In some parts of state, rainfall was less than 50 percent of normal, and January and February figures show drought to be continuing with unabated force. Ohio River for many months consisted of series of long pools of nearly stagnant water. Resulting decay of organic matter and increased concentration of dissolved solids, together with industrial wastes, produced taste which was referred to as "river taste." Employment of excess lime as disinfectant and discontinuance of chlorination served greatly to minimize taste problems at Bellaire and Ironton. At Delaware, Ohio, potassium permanganate at rate of 3 pounds per million gallons, followed by lime treatment to precipitate manganese, was successfully employed for 3 days. Ammonia-chlorine process was used at Warren, Marietta, and other places, and although it prevented tastes of phenolic nature it was unsuccessful in modifying the characteristic river taste. Application of powdered activated carbon to raw water removed the disagreeable taste at Huntington, W. Va. Other effects of drought included increase in hardness of Ohio River water and increase in maximum rates of pumpage. Ratio of maximum hourly consumption to average daily consumption at Columbus increased from 1.85 to 2.15. Deep well supplies held up satisfactorily throughout period of depleted water supply, but water table has now dropped to point where it is causing failure of some deep wells. Rainfall in Maryland during 1930 was relatively the lowest of entire country, being only 56 percent of normal; 23.4 inches compared with average of 41.8. Depleted supplies and increasing salinity necessitated emergency measures in many communities. Drought began in December, 1929, and has continued to present day, with exception of slight relief in December, 1930. Conditions in individual communities in each of states mentioned are described.—*R. E. Thompson.*

New Waterworks of the Town of Potsdam near Elche, Germany. O. Sprung. Gas und Wasserfach, **74**: 46, 1052–1059, November 14, 1931. Underground river is drawn upon for town supply; at present for 5,000, but ultimately to be for 20,000, cubic meters per day. Water contains iron and manganese, has 215 p.p.m. hardness and pH of 7.9. Description is given of pumping plant and of iron and manganese removal by aëration and double filtration.—*W. G. Carey.*

Bore-Hole Pumping Plant. Anon. The Engineer, **153**: 3970, 194, February 12, 1932. Submersible A.C. motor, placed below pump, into which water is freely admitted and acts as cooling medium, is the feature. Stator coils are enclosed in air- and water-tight welded container. Pump is of normal multi-stage design. Only delivery pipe and cables enclosed in special hose pipe, impervious to water, pass down well, so that even if bore-hole be not vertical, or even not straight, result is still satisfactory, provided pump and piping can be lowered. Another recently developed arrangement utilizes ejector principle to bring water from great depth to pump placed on ground level, only apparatus within bore-hole being double pipe and ejector cones.—*W. G. Carey.*

Vals de Loire Water Supply. Anon. The Engineer, **153**: 3971, 225, February 19, 1932. Method for obtaining million cubic metres of water daily for Paris by pumping from wells in sandy bed of Loire valley has been modified to gravitation scheme. Water is to be obtained from natural filtering bed 43 miles long and half mile wide which collects water from Loire and valley. A 14-foot main is to be laid at bottom of sandy stratum for 40 miles with sufficient inclination and with branching feeders. Main will be connected with aqueduct 90 miles long and 18 feet in diameter, for delivery by gravitation to Paris.—*W. G. Carey.*

Shutting off Bad Water in a Deep Well. Anon. Railway Engineering and Maintenance, **28**: 8, 501, 1932. The 8-inch diameter by 556 feet deep well, installed by Texas and Pacific RR. in 1924, originally furnished water with only 9.0 grains per gallon hardness. In December, 1930 it was found that hardness had increased to 40 grains, due to leaks in casing at 41-foot and 432-foot levels. Leak at 41-foot level was stopped by pumping cement grout down through 2-inch pipe on outside of casing with 10-foot burlap plug in well. Leak at 432-foot level was plugged by filling bottom 83-foot slotted screen section with thick mud, sealing, and then pumping cement grout down into casing under 130 pounds pressure, followed by enough clear water to clean the casing of grout. After setting 7 days, well was cleaned and 48-hour pumping test showed hardness back at original 9.0 grains per gallon.—*R. C. Bardwell* (*Courtesy Chem. Abst.*).

Centrifugal or Reciprocating Pumps. E. M. Grime and W. H. Armstrong. Railway Engineering and Maintenance. **28**: 9, 561, 1932. Centrigufal pumps are preferred for railway service, due to their simplicity, lower first cost, and lower maintenance.—*R. C. Bardwell.*

Track Pans Without the Usual Problems. Anon. Railway Engineering and Maintenance, **28**: 9, 552–555, 1932. New York Central RR. has completed modernization of their four main line tract pan water station at Rome, N. Y. Water consumption will average over 1,000,000 gallons per day. Track pans are 20 inches wide by 8 inches deep and from 2,000 to 2,500 feet long. Pans are cross-connected at intervals of about 355 feet with 14-inch water mains, for rapid filling, which is controlled by float valves. Steam line 2,700 feet long with laterals each 32 feet provides for heating during winter season.

Entire roadway, between tracks and on shoulders, is paved with concrete blocks and complete system of sub-drainage is provided. Cost of maintenance has been materially reduced. Plans and photographs are shown.—*R. C. Bardwell.*

Better Water Conditions Pay Large Dividends. Anon. Ry. Age, **92**: 24, 973–975, 1932; Railway Engineering and Maintenance, **28**: 6, 382–386, 1932. During past 8 years, Baltimore & Ohio RR. has installed 113 water softening plants, giving them total of 123 treated water stations on lines from Philadelphia to Chicago, and from Cumberland to St. Louis. Of these 123 plants, 115 are of lime-soda type and 8 are zeolite. About 90 percent of water used, or or over 7 billion gallons annually, is treated, over 10 million pounds of scaling matter, which would otherwise have gone into boilers of locomotives, being removed. Large amount of mud is also removed and acidity, which occasionally runs as high as 10 grains per gallon, is neutralized. Automatic operation is featured wherever possible. Annual net saving of over $1,000,000 is estimated as resulting from improved water quality. Typical plan details and photographs are given.—*R. C. Bardwell* (*Courtesy Chem. Abst.*).

Elimination of Taste in Water passing through Creosoted Wood Stave Pipe. J. F. Harkom and C. Greaves. Engineering J., **14**: 515–17, 1931. From Bulletin of Hygiene, **7**: 1, 51, January 1932. Creosoted pipes may be used to carry unchlorinated water without creation of abnormal taste, although considerable quantities of creosote may be dissolved. With chlorinated water, too much creosote is dissolved to be removed by superchlorination and dechlorination. Activated carbon has been found so effective in removing creosote from water passing through such pipes, that after filtration it may be successfully chlorinated.—*Arthur P. Miller.*

The Behaviour of Bacteriophage Present in Raw Water in the Process of Sand Filtration. A. D. Stewart and S. C. Ghosal. Indian Jour. Med. Research, 1931, **19**: 137–43. From Bull. of Hygiene, **7**: 1, 61, January, 1932. Study of fate of bacteriophage in slow and rapid sand filtration of raw river water showed no evidence that it played any part in purification process. Sand filtration seems to free raw river water more or less from the bacteriophage which it contains and a 90 to 99 percent reduction in concentration of bacteriophage was observed during three days settlement without use of alum, while with alum reduction of as much as 90 percent was accomplished within a few hours. In slow sand filtration, lytic principles examined were in most instances completely removed, whereas in rapid sand filtration some varieties of bacteriophage were completely removed while others showed a high reduction.—*Arthur P. Miller.*

Study of the Presence of Bacteriophage in Surface Waters. E. Gildemeister and H. Watanabe. Zent f. Bakt. I. Abt. Orig., 1931, **122**: 556–75. From Bull. of Hygiene, **7**: 2, 118, February, 1932. Tests of bacteriophage content of samples of water drawn from River Spree, from various Berlin canals, from several lakes, and from other sources showed it to be in every case directly cor-

related with degree of fecal contamination. Samples were collected after dry and after rainy weather. Each sample was tested against many different organisms belonging to the coli, dysentery, and typhoid-paratyphoid groups. Bacteriophage was abundant and active in highly contaminated waters, especially after wet weather, whereas it was very low in uncontaminated water.—*Arthur P. Miller.*

The Origin of "Chemist's Shop Flavor" in Drinking Water. W. UGLOW and M. BOLTIN. Ztschr. f. Hyg. u. Infektionskr., 1931, 112: 655–9. From Bull. of Hyg., 6: 12, 900, December, 1931. Production of chlorophenols and its prevention either by alkalization of the water with ammonia, or with alkali carbonates, or by large doses of chlorine and subsequent dechlorination. Filtration through carbon filters for odor removal is also mentioned.—*Arthur P. Miller.*

(1) **Remarks on Some Clinical Pictures Attributable to Lead Poisoning with Special Reference to the Neurological Manifestations of Plumbism.** E. BRAMWELL. Brit. M. J., 1931, July 18, 87–92. (2) **Cumulative Effects of Infinitesimal Doses of Lead.** N. PORRITT. Ibid., 92–4. From Bull of Hyg., 6: 12, 865, December, 1931. Four clinical pictures attributed to lead poisoning are given. In each case, lead was found to have been present in the drinking water. In the second article, cases of lead poisoning are recorded where $\frac{1}{1}$ and $\frac{1}{0}$ grain of lead per gallon were found in drinking water. It is pointed out that where plumbo-solvent water originating from the moors is in use, maternal mortality is high, with high death rate from eclampsia.—*Arthur P. Miller.*

Untreated Ground Water Supplies are Potential Hazards. C. H. EASTWOOD. The American City, 46: 3, 66–70, March 1932. Acceptance of purity and sterility of underground drinking waters is becoming increasingly questionable. Study of sub-surface supplies in Kansas brought out fact that less than one percent of them had perfect bacteriological records for eight to nine years. Defects of underground supplies and results of those defects in particular supplies are well described and illustrated. Wells, springs, mine drainage, and infiltration galleries are all discussed. Public statistics of this decade show that 16.6 per cent of all cases of typhoid fever and dysentery came from untreated ground water supplies, while 2.3 per cent came from untreated surface waters. This shows how false is the feeling of security in connection with ground water supplies. Entire article is a well-balanced argument for purification of ground waters as a protection against disease.—*Arthur P. Miller.*

Improving Water-Works Service with an Elevated Storage Tank. Anon. The American City, 46: 3, 80–81, March 1932. To improve operating conditions, Indianapolis Water Company decided to install 1½-million-gallon, radial-cone-bottom elevated tank. Size and location of the tank were determined only after considerable study of distribution system. Heavy drafts due to extremely hot weather and taxing the booster pumps to the limit were one reason for installing the storage tank, which has been found to provide better service by maintaining higher and more adequate pressure in regions

of greatest demand, and by eliminating violent changes in pressure due to heavy drafts. Maximum rates both of primary and of secondary pumpage during peak loads have been reduced, and insurance rating, favorably affected.—*Arthur P. Miller.*

Cleaning an Impounding Reservoir with a Suction Dredge. Anon. The American City, **46**: 2, 69–70, February 1932. Organic matter and mud in Macopin intake reservoir of Newark, N. J., water supply have been causing turbidity. This reservoir, with capacity of 32 million gallons, is used as collecting and settling basin. The deposits, too inert to remove by straight suction, are being taken out by combined suction and cutter methods, supplemented by hydraulicing of the deposits on the rocks exposed when the reservoir is drawn down. Hull of suction dredge is made of two pontoon sections of electrically welded steel, each 31 feet long, 7 feet wide, and having draft of 2 feet. It carries a full-size 6-inch suction dredge, which will dig to a depth of 10 feet below water, and the sections are light enough to be transported by truck to any land-locked water supply. Hydraulic equipment includes three 1¼-inch nozzles which work at 92 pounds pressure, 2500 feet of piping with fittings, and high-pressure hose lines. Scouring with water through these high-pressure nozzles is done manually and is very successful. —*Arthur P. Miller.*

The Present Water Works of Baltimore and the Additions Proposed. Charles F. Goob. The American City, **46**: 2, 77–78, February, 1932. First part of this article describes present water works of Baltimore. Vernon pumping station, electrically operated, has just been completed. Pumping units of 30, 40, and 50 million gallons capacity operate against net head of 60 pounds. Hillen pumping station has two 20-million and one 30-million-gallon-per-day units. In the Guilford pumping station are two 10-million and two 15-million-gallon-per-day pumping units, arranged to work automatically. This station is in residential section, where noise is objectionable, and was designed accordingly. Prettyboy dam on upper Gunpowder River, designed to give 20 billion gallons of storage is under construction. This structure will be 140 feet from foundation to crest. New 14,000-foot tunnel of 84-inch inside diameter, at depth varying from 60 to 100 feet, will soon connect New Montebello filtration plant to Druid Lake.—*Arthur P. Miller.*

The Scope and Chief Problems of Regional Limnology. Naumann, E. Intern. Rev. ges. Hydrobiol. u. Hydrog., 1929, **22**: 423. (In English.) Waters of regions differing in geological structure differ in biological character and can be grouped under a few types according to regional variation of physical, or chemical, factors. Most important physical factor is temperature; and regional division is into arctic, temperate, and tropical zones. As regards chemical factors, most important are lime content and pH and humus, nitrogen, and phosphate contents, values for all of which are given for waters of polytrophic, mesotrophic, and oligotrophic types. Importance of regional limnological mapping of countries is discussed and preparation of such a map of Sweden is described. Description is given of application of method to

specific study of lake types, and present state of such study in various countries is referred to. Bibliography appended contains 170 references. *M. H. Coblentz (Courtesy of the department of Scientific and Industrial Research, Water Pollution Research Board, Summary of Current Literature).*

Studies on the Scottish Marine Fauna: the Fauna of the Sandy and Muddy Areas of the Tidal Zone. STEPHEN, A. C. Trans. Roy. Soc. Edin., 1929, 56: 291. Extending his study of fauna of intertidal sands in the Cumbrae, Firth of Clyde, author examined intertidal fauna in 25 localities on Ayrshire coast, Firth of Clyde, south coast of Moray Firth, Aberdeenshire coast, St. Andrews Bay, and Firth of Forth. The variations of fauna are described.—*M. H. Coblentz (Courtesy of the Department of Scientific and Industrial Research, Water Pollution Research Board, Summary of Current Literature).*

Report of the Meeting of the Committee on Standard Processes for Water Examination, November 25, 1929. Verein Deutscher Chemiker. Z. angew. Chem., 1930, 43, 53. Preliminary work on standard methods for examination of drinking and industrial water and of sewage was reviewed. The I.G. Farbenindustrie A.-G. has been responsible for publication in two volumes of preliminary work on drinking-water methods. It was arranged that mineral waters should also be dealt with. Standard processes will be published during 1930, in series of leaflets, by the Verlag Chemie G.m.b.H. with support of German Society of Chemists. (Tech. Gemeindebl., 1930, 33: 5.).—*M. H. Coblentz (Courtesy of the Department of Scientific and Industrial Research, Water Pollution Research Board, Summary of Current Literature).*

Process for the Control of the Composition of a Water Supply, Utilising Color Indicators and Acid or Alkaline Reagents. ARBATSKY, I. G. P. 437,967; Deutsch. Zuckerindust., 1930, 55: 121. Patent concerns a single mixed indicator, which gives clear color change between weak and strong alkalinity, consisting of methyl red and thymol-phthalein, or similar agent showing blue coloring near weak alkalinity, with small addition of phenolphthalein, or similar agent which shows suddenly in neighborhood of weak alkalinity a color other than blue. By this means process of control is simplified, in that only a single indicator test is necessary; determination of magnesium salts, which have a weak alkaline reaction, is specially clear. Control of boiler water is also simplified, because by this process presence of excess of any constituent can be determined. Use of the indicator in conjunction with other tests on same sample and drop arrangement for its application are also described.—*M. H. Coblentz (Courtesy of the Department of Scientific and Industrial Research, Water Pollution Research Board, Summary of Current Literature).*

The Determination of Hardness in Water by a Soap Solution. ESTREICHER, T. V. Chem. Ztg., 1929, 53, 800. In reference to BRUHNS's paper (Chem. Ztg., 1929, 48, 469) author points out that OLSZEWSKI in paper entitled "A contribution to the determination of hardness in water by a soap solution" (Trans. Cracow Academy of Science, 1881, 9, 173. In Polish), proved that transitory lather appeared at moment of complete consumption of calcium and

could therefore be used for measurement of lime hardness. He later verified his results by many experiments. Only difference between his method and that of BRUHNS was that OLSZEWSKI removed carbon dioxide by boiling, or by current of CO_2-free air, while BRUHNS neutralised it with 0.1 *N* sodium hydroxide. Accuracy, according to OLSZEWSKI's experiments, is greater than that claimed by BRUHNS, whose results generally confirm those of OLSZEWSKI and show that it is possible to determine lime and magnesium hardness in one operation—*M. H. Coblentz* (*Courtesy of the Department of Scientific and Industrial Research, Water Pollution Research Board, Summary of Current Literature*).

The Bacteriology of Water. HENRY, H. A system of bacteriology in relation to medicine, **3**: Chap. 2, 38. H.M.S.O., London, 1929. Author gives very brief survey of bacteriological questions connected with water, water supplies, and sewage purification. Two main groups of water bacteria are distinguished, those naturally occurring in water, or in surface soil, and those which indicate fecal pollution. As factors influencing bacterial content of water, rain, pollution, temperature, sedimentation, bacteriophage action, and sunlight are briefly discussed. Bacteriological examination of water supplies includes quantitative estimation of bacterial content and detection and enumeration of excretal organisms. Methods for distinguishing colon bacilli and for distinguishing typical *B. coli* from *B. aërogenes*, and use of the coli index in judgment of a water are described. Brief notes are given on fecal streptococci and fecal anaërobes in water. Methods used in bacterial examination of sewage are similar to those used for water. Of great importance are parts played by different bacteria in purification processes of sewage. Present state of knowledge of action of aërobic and of anaërobic bacteria in these processes is briefly discussed. References to the literature are given.—*M. H. Coblentz* (*Courtesy of the Department of Scientific and Industrial Research, Water Pollution Research Board, Summary of Current Literature*).

The Method of Bacteriological Water Examination. ANGERER, K. v. Handbuch der biologischen Arbeitsmethoden. IV. Angewandte chem. und physik. Methoden, part 11, No. 2; Wass. u. Abwass., 1929, 26, 192. Explanations are given of significance of total bacterial content, of technique of taking samples, and of detection of certain species of bacteria of hygienic and sanitary significance.—*M. H. Coblentz* (*Courtesy of the Department of Scientific and Industrial Research, Water Pollution Research Board, Summary of Current Literature*).

Growth and Acid Formation of Aspergillus Niger under Water. AMELUNG, H. Chem. Ztg., 1930, 54, 118. Research has shown that the acid formed by strains of *Aspergillus* is not increased by aëration beyond amount usually formed in stoppered culture flasks. Author carried out experiments to test acid formation by *Aspergillus japonicus* in higher layers of liquid with avoidance of surface growth. Experiments were carried out in culture solutions saturated with oxygen by blowing compressed air through them. One series of cultures was kept for 30 days at 35°C.; second series was kept for 10 days

at 35°C. and then at room temperature; third series was kept at 35°C. and neutralised after five days with calcium carbonate; to fourth series, sufficient soda solution to secure only weakly acid reaction was added every five days. Experiments showed that fungus would grow under water with sufficient aëration and that it did not form any considerable quantity of acid. More acid developed in shallow layers of liquid with surface growth and without artificial aëration. Neutralisation with calcium carbonate had little influence; but neutralisation with soda affected both acid formation and fungus growth unfavourably.—*M. H. Coblentz* (*Courtesy of the Department of Scientific and Industrial Research, Water Pollution Research Board, Summary of Current Literature*).

The Removal of Scale from Water Spaces. Anon. Engineering, 133: 3458, 493–4, 1932. To find rapid and safe method of removing scale from water spaces of Diesel engine, Messrs. Mirrlees, Bickerton, and Day Ltd., of Stockport, England, conducted research which led to production of "Mirrlees Inhibitor." It is to be added to hydrochloric acid to reduce that acid's action on metal without decreasing its action on scale. Experiments showed that addition of one part by weight of inhibitor to ten parts by weight of hydrochloric acid would reduce to within safe limits action of acid on metal. For removal of scale from aluminum alloys, acid strength should not exceed 10 percent. In case of the alloys, inhibitor reduces action only about 50 percent. Composition of inhibitor is not given.—*G. L. Kelso* (*Courtesy Chem. Abst.*).

Water Board Does Great Service. Illinois Health Messenger, 3: 18, 69, September 15, 1931. Clothed with legal power to deny to individuals, or corporations, privilege of emptying contaminated wastes into streams, lakes, and pools of State, and authorized by law to order abatement of stream pollution, Ill. State Sanitary Water Board has accomplished remarkable volume of results during 22 months since its organization. Complete elimination of pollution, or significant progress toward that end, has been accomplished in 700 miles of streams which involve about 110 separate water courses and 9 ponds and lakes. Water Board is made up of directors of State Departments of Agriculture, Conservation, Purchases and Construction, and Public Health. Fifth member is representative of industry selected by the Governor.—*G. C. Houser.*

The Year in Review. Public Health News (N. J. Dept. of Health), 16: 10–11, 195, September–October, 1931. New low death rate for typhoid fever is among records listed in report of State Department of Health of New Jersey for year ending June 30, 1931. Only 45 persons died from typhoid fever in State during 1930, making a death rate for this disease of 1.10 per 100,000. In 1929, deaths numbered 52, whereas ten years ago annual fatalities of 125 and more were usually recorded. New Jersey residents were fortunate during drought of 1930 in having sufficient water for large city supplies so that extra water from polluted streams was not needed. There were no epidemics of water-borne disease and no mass complaints of objectionable tastes and odors. This speaks well for the operation of the 300 and more public water works in the State.—*G. C. Houser.*

Sanitary Engineering News Items. Monthly Bulletin, Ind. State Board of Health, **34**: 10, 153, October, 1931. Bids were received November 3 on construction of second unit of Three Rivers filter plant at Fort Wayne, Ind. This unit includes sedimentation facilities, filtration plant, softening plant and pumping equipment. U. S. Public Health Service, enforcing provisions of interstate quarantine regulations, have established water supplies in use at Indianapolis and South Bend airports as watering points for planes in interstate traffic. Contracts have been awarded and construction is now under way on water filtration plant for Petersburg, Ind. To date, water furnished the public in Petersburg has been pumped directly from White River, with no treatment whatever.—*G. C. Houser.*

Sanitary Engineering News Items. Monthly Bulletin, Ind. State Board of Health, **34**: 11, 172, November, 1931. Contracts have been awarded for construction of modern water purification plant for town of Paoli, Ind., consisting of sedimentation basin and gravity filters, to replace existing pressure filter equipment. Survey of pollutional factors affecting Patoka River is being carried out by Indiana State Board of Health. Investigation covers section of river from Jasper to the Princeton water works intake. At a popular election by voters of Milan, Ind., it was decided to proceed with development of new public water supply for that community. Plans and specifications for this water supply system have been approved by State Board of Health.—*G. C. Houser.*

Recent Public Health Achievements in Illinois. ANDY HALL. Illinois Health Quarterly, **3**: 4, 239, October–December, 1931. New low death rate from typhoid fever was established recently. This disease caused only 2.0 and 1.4 deaths per 100,000 in 1930 and 1929 respectively. Rate was 2.2 in 1928, the previous low record year. Creation of Sanitary Water Board in 1929 promoted efficiency and economy of stream sanitation and conservation work by doing away with former overlapping activities of separate State departments. Sanitation of streams and public water supplies was greatly aided by putting into commission a complete laboratory on wheels. In 1931, law was enacted which places supervisory, instead of advisory, duties on State Department of Public Health relative to public water and sewer systems.—*G. C. Houser.*

Iron Gives Bad Taste to Water. Public Health News (N. J. Dept. of Health), **17**: 1–2, 21, December, 1931–January, 1932.—Three samples of water sent to laboratory of New Jersey State Department of Health recently, because the waters were said to be "bad," illustrate real causes of certain complaints. One sample came from driven well, about 20 feet deep; another from dug well; and the third from tap on public supply. Tests showed all three to be free from bacteria of dangerous character. Iron, however, was found in excessive quantities in each sample and was believed to be to blame for complaints. The two wells were at base of mountain ridge from which iron ore has been mined for generations. Tap on public water supply was in house near a dead end and at some distance from other houses.—*G. C. Houser.*

Illinois Enjoyed Good Health in 1931. Illinois Health Messenger, **4**: 1, 1, January 1, 1932. Incomplete reports indicate that 1931 was year of unusually favorable health conditions in Illinois. Fatalities and sickness from typhoid fever declined sharply below 1930 experience. For first time in 30 years, water of Wabash River through and below Illinois oil well district was made serviceable for sporting, for local water supplies, and for cattle in that area. While stream sanitation work got under way in 1929, bulk of what has been accomplished took place during 1931.—*G. C. Houser.*

Then and Now. T. B. APPEL. Pennsylvania's Health, **10**: 1, 4, January–February, 1932. When Pennsylvania Department of Health was organized in 1905, there were possibly a dozen filtration plants in state, chiefly in small municipalities and for purpose of clearing oily water. Now state has more than 200 plants filtering and chlorinating water supplies for more than 6,000,000 people, while more than a million others are served chlorinated water from sources not requiring filtration. In 1906, typhoid was rampant both in city and on farm. It then caused 3,917 deaths annually, a rate of 54.8 per 100,000. In 1928, there were 194 deaths, a rate of 2.0. Last year, directly due to drought conditions, 247 Pennsylvanians died from typhoid, a rate of 2.6. The disease has been practically eradicated from municipalities.—*G. C. Houser.*

The Bureau of Engineering. H. E. MOSES. Pennsylvania's Health, **10**: 1, 54, January–February, 1932. Obvious remedy for typhoid epidemics in Pennsylvania was first of all development of safe water supplies under authority conferred upon Commissioner of Health by Purity of Waters Act of 1905. This became, and is now, most important activity of Bureau of Engineering. Development of quite recent years in Pennsylvania is installation of plants for rectification of water, such as those for softening, and for iron and manganese removal. There are 22 such plants in Pennsylvania. During drought of 1930, in 48 counties, 125 communities were obliged to use either auxiliary, or emergency supplies, or both, and in 41 counties, 96 places were forced to secure new supplies and use them for several months. No typhoid fever outbreak could be attributed to any normal or emergency public supply.—*G. C. Houser.*

Purity and Quality of Connecticut Carbonated Beverage Waters. C. C. CARLSON and F. L. MICKLE. Connecticut Health Bulletin, **46**: 2, 31, February, 1932. Supervision of waters used for carbonated beverages, or for bottling, in Connecticut is duty of State Dairy and Food Commissioner. Bureau of Laboratories of State Department of Health makes laboratory examinations. Total of 775 laboratory examinations on water samples from 115 sources have been made during five-year period. Well and spring supplies have been classified into satisfactory, doubtful, and unsatisfactory. The 1931 figures show improvement over previous years. Fact that 81 percent of supplies under active supervision are classed as satisfactory, while only 3 percent are definitely unsatisfactory, indicates high quality of water used by Connecticut manufacturers of carbonated beverages.—*G. C. Houser.*

Crawfish Holds Check Valve Open. Connecticut Health Bulletin, **46**: 2, 39, February, 1932. In 1926, Connecticut State Department of Health pro-

mulgated regulations prohibiting new cross connections between potable water systems and unapproved auxiliary water supplies and allowing old connections only if provided with double check valves of special design, equipped with drip cocks and gages for testing. During recent inspection, test showed valve to be leaking. It was found that live crawfish had entered water main and as it was passing through check valve, valve had closed upon claws of crawfish. Second valve was holding tight, however, so that no polluted water was getting into public main.—*G. C. Houser.*

Eliminating Tastes and Odors from New Jersey Water Supplies. LEROY FORMAN. Public Health News (N. J. Dept. of Health), **17**: 3–4, 35, February–March, 1932. Complaints of disagreeable tastes, or odors, in 10 public potable water supplies in New Jersey have been investigated by Bureau of Engineering during last few years. Hydrogen sulphide was removed by aëration. Algae were destroyed by copper sulphate and chlorine. Ammonia gas treatment gives great promise of solving odor and taste problems due to phenols. Four large chloramine treatment plants are in successful operation in N. J. Tastes due to excessive organic matter were removed by storage in large reservoir; during long detention period, water had time to undergo oxidation and aëration. In new mains recently laid for one of largest water supplies in N. J., 8 p.p.m. of chlorine were used to flush out pipes for several days, and, at end of this time, solution containing 8 p.p.m. of Cl was allowed to remain quiescent therein for a day or two and mains again flushed.—*G. C. Houser.*

Time to Fight Typhoid Fever. Illinois Health Messenger, **4**: 7, 28, April 1, 1932. With high degree of certainty it may be predicted that typhoid fever is just around the corner. Season opens at beginning of warm weather and reaches peak in September. Several hundred cases may be expected to develop in Illinois during 3 or 4 months. For a large percentage of people in southern third of State, most practicable means of prevention is vaccination. This is true because many homes are not provided with either public water supplies, or public sewer facilities. Last year 127 people died and 804 were sick from typhoid fever in Illinois, death rate being 1.6 per 100,000.—*G. C. Houser.*

Efficient Production of Manufactured Ice. DANA BURKE, Jr. Ind. Chem., **24**: 605, 1932. It is demonstrated that, by using brine at 6°F., instead of at the usual 16°F., with more thorough agitation, most waters can be successfully used to produce a clear ice cake.—*Edw. S. Hopkins* (*Courtesy Chem. Abst.*).

Advantages of Mechanical Removal of Sludge in Water Softening Plants. FRANK BACHMANN. Ind. Eng. Chem. (News Ed.), **10**: 125, 1932. Discussion of advantages of continuous mechanical cleaning of sedimentation basins. There are 49 such installations in this country. This procedure eliminates sudden increased mud loads on streams resulting when wastes from these basins are periodically discharged; reduces odor conditions; and prevents loss of water, since basins are not dewatered.—*Edw. S. Hopkins* (*Courtesy Chem. Abst.*).

Acid Treatment of Incrusted Water Wells. Part II. Anon. Johnson National Drillers Journal, May, 1932. "Single Acid Treatment" involves use of muriatic acid and is suitable where predominating constituent of encrustation is silica. In its use all fittings and pipe should be black; not galvanized. A pipe is lowered to botton of screen and sufficient acid is poured through it to fill the screen. Acid then stands for one to two hours before stirring; thereafter, for eight to ten hours with occasional stirring. Surge block is then lowered into well and well is surged lightly for a few minutes. After period of rest of three to four hours, well is surged heavily. It is cleaned with bailer and pumped for an hour or more, preferably with pump at bottom of well. "Double Acid Treatment" is advised where organic material and calcium carbonate are approximately equal to silica in encrusting material. In this procedure "Single Acid Treatment" is first applied. Screen is then filled with sulphuric acid and allowed to stand two to four hours; surged lightly for ten minutes; let stand for one or more hours; surged heavily for fifteen minutes; bailed clean; and then pumped for two hours, or more, with precautions taken to assure complete removal of acid. When compressed air is available, it is used for heavy surging. "Dry ice" is also used successfully for surging.—*H. E. Babbitt.*

A Convenient Method for Determining Drawdown in Wells. Anon. Johnson National Drillers Journal, June–July, 1932. To assess capacity of a well, three things must be determined: (1) rate of pumping, (2) static water level, and (3) the drawdown when pumping. These three terms are defined. Method described depends upon use of small air pipe between pumping pipe and casing. The falling level of water in well is shown by change in air-pressure in small pipe. Relation between drawdown and discharge is discussed and results of tests to show relation are shown graphically.—*H. E. Babbitt.*

The Hydrology of Industrial and Municipal Water Supplies in Illinois. W. D. GERBER. Circular No. 11, Illinois State Water Survey Division. Water of good quality is never expensive. At ordinary prices, a 5-foot cube of water would cost about 23¢; if frozen into ice it would retail for $49.00. There are three distinct zones of water supplies in Illinois. In northern zone, water supplies are secured from deep, or rock, wells; in central zone, from wells in "drift" deposits of sand, gravel, and clay; and in southern zone, from surface sources. The heavy draft on northern zone sources is causing recession of 5 to 8 feet per year in water table. In central zone, waters vary greatly in character and volume; being usually inadequate in quantity, highly mineralized, and hard.—*H. E. Babbitt.*

The Montreal Water Supply. C. J. DESBAILLETS. Am. Journal of Public Health, **22**: 6, 627, June, 1932. Brief history of development of the supply and works is given. At present water is taken from St. Lawrence River and delivered to the filter plant through canal 7 miles long. Distribution system is divided into three zones, due to the various elevations on which city is built. Low-level pumping station, which pumps the total supply of water, is

equipped with six 30-m.g.d. electrically driven pumps. Equipment and arrangement of other pumping stations are described.—*H. E. Babbitt.*

An Investigation of the Montreal Typhoid Epidemic of 1927. H. D. PEASE. Am. Journal of Public Health, 22: 6, 654, June, 1932. Primary outbreak of approximately 2,600 cases, reported during March and April, was followed by remission of 3 weeks and then by sharp recrudescence of nearly as many cases in May. A total of 5,353 cases developed, with mortality of approximately 10 percent. Geographic distribution of cases and that of milk supplies of two companies were in close harmony. Employment of typhoid carriers and mishandling of milk in pasteurization process were shown by the investigation.—*H. E. Babbitt.*

Interpretation of Laboratory Findings in Rural Spring Water Supplies. E. K. KLINE and N. M. FULLER. Am. Journal of Public Health, 22: 7, 691, July, 1932. Attempts to reconcile results of sanitary surveys and of laboratory examinations of rural water supplies of Cattaraugus County, N. Y. indicated that in supplies from springs, certain periods of the year when laboratory findings became distinctly unfavorable were coincident with appearance of small numbers of salamanders in the springs. They live in large numbers buried deep within the shale along the underground streams. At certain seasons they come out to the surface and travel overland at least 65 feet. Here they feed on insects, worms, fly larvae, or similar living food. Should these be infected with *B. coli* the salamanders become infected. They return to the depths and throw off *B. coli* for a considerable time. Laboratory tests on such a water supply would suggest condemnation even though supply were otherwise unpolluted.—*H. E. Babbitt.*

A Study of the Pulaski Reservoir. F. J. SETTE. Virginia Polytechnic Institute. Bulletin No. 8, Eng'g Exp. Sta. Series. March 1, 1932. Purpose of study was to discover causes for development of tastes and odors in the water and to study cause of pipe line tuberculation with view to minimizing the trouble. Watershed, reservoir, and dam are described and general conditions and procedure during test are outlined. Chemical, physical, and biological studies were made. In synopsis of conclusions, it is stated that water taken into distribution system during late summer and fall may be low in dissolved oxygen and high in carbon dioxide. Some iron from pipe goes into solution, due to electrolytic action. It is precipitated as ferric hydroxide by dissolved oxygen. There is also deposition of organic matter in pipes, decomposition of which increases carbon dioxide content and decreases dissolved oxygen content. Because of softness of water, presence of carbon dioxide increases its corrosiveness. Tuberculation is due more to deposition of ferric iron than to action of iron bacteria. Red water is produced. Scraping and cleaning pipe and adding lime to the water during periods of greatest difficulty might minimize undesirable results. Tastes and odors are due mainly to protozoa. Algae should not cause any trouble because of small numbers found.—*H. E. Babbitt.*

The Cause of Mottled Enamel, a Defect of Human Teeth. M. C. SMITH, E. M. LANTZ, and H. V. SMITH. Bull. No. 32, Ag. Exp. Sta., University of Arizona, June 10, 1931. Mottled enamel is tooth defect endemic in certain communities, chiefly characterized by the presence of dull, chalky, white, or paper-white, patches distributed irregularly over surface of tooth. Difficulty occurs during formation of enamel. Normally formed teeth have never been known to become mottled later. Study reported was made on 250 inhabitants in St. David, Arizona. Studies, experiments, and proofs presented lead logically to conclusion that water supply is source of the trouble, which is shown to be due to destructive action of fluorine present in water supplies of afflicted communities. Bibliography is appended.—*H. E. Babbitt.*

New Water Supply at Yorkton, Sask. M. SINCLAIR. Canadian Engineer, 62: 11–13. January 19, 1932. Electrically driven pump, with gasoline engine stand-by unit, pumps water to 150,000-gallon (Imp.) tank. In event of fire pressure being necessary, tower water can be turned into fire pump suction in addition to fire storage in reservoir, tower being protected from high pressure by check-valve.—*R. H. Oppermann.*

The Effects of Frost on Water-Charged Lead and Copper Pipes. C. E. LARARD and F. A. W. OLIVER. Engineering, 133: 673–677, June 10, 1932. Research carried out to determine effects of one or more refrigerations on sealed tubes and to investigate behaviour of certain well-known types of joints for connecting copper tubes. Results show conclusively that no sealed water-filled copper tube withstood more than two complete refrigerations without fracture and that most copper tubes burst on first freezing; whereas no water-charged lead pipe fractured under less than five successive refrigerations, while in one case ten refrigerations were necessary to produce fracture, due to relatively great ductility of lead as compared with that of copper of "hard," or "moderately hard" solid-drawn tubes. "Dead soft" copper tubes have almost same margin of safety as lead pipes, but their practical disadvantage is that they are difficult to transport and handle and, when fixed, are liable to sag, unless supported very efficiently. Results on couplings showed that they were strong as, if not stronger than, tube itself.—*R. H. Oppermann.*

NEW BOOKS

Vom Wasser, 5, 1931. Verein Deutscher Chemiker. Verlag Chemie, G. M. B. H., Berlin 1931. (Further Selected Papers.) **Salt Content and Hardness of Hamburg's Water Supply.** G. NACHTIGALL. 18–31. Paper illustrated by nine charts, giving volume of flow and chloride content of river Elbe water and chloride and hardness contents of Hamburg's water supply taken formerly wholly and still partly therefrom. So much chloride-containing waste is discharged into Elbe, that chloride content of supply has been as high as 350 parts per million. Since 1922, average has been well below the officially established maximum of 250 parts per million, partly due to coöperation of factories with river authorities. **Nitrification Reactions in Rapid Filters.** T. Folpmers. 32–46. Nitrification processes at three different depths in Paterson rapid filter were

investigated and results are given in series of charts and tables. Nitrification took place throughout the filter but particularly in uppermost layer tested. During oxidation of saline and albuminoid ammonia and nitrites to nitrates, oxygen is consumed and carbon dioxide liberated, while hydrogen ion concentration increases. Nitrification takes place even at temperatures of −2°C. Construction of rapid filter is described and illustrated and grading of sand given. **Observations on Water of High Bacterial Content in Presence of Iron.** W. AUSTEN. 52–56. Water of high bacterial content in neighbourhood of land irrigated with sewage had iron content of 48 parts per million; aggressive carbon dioxide, 79.2; and sulphate (SO_3), 202.4 parts per million, but no oxygen. Black precipitate of iron sulphide on well walls, thought to be due to reduction by nascent hydrogen of sulphate, proved to be probably formed by bacterial action; oxidation of sulphide to sulphate took place on exposure to air, with further decomposition of sulphate to oxide (rust). **The Oxygen Question in Boiler Operation.** A. SPLITTGERBER. 134–146. Unless water is alkaline, it has solvent action on iron, even though oxygen absent, proceeding until equilibrium reached depending on pH of water. Equilibrium is disturbed by oxygen which converts dissolved ferrous oxide to ferric oxide when more iron is dissolved. Electrolytic action caused by variations in composition of boiler metal produces pitting. Amount of oxygen in solution at temperature and pressure of boiler operation is negligible, but oxygen expelled from feed water as bubbles would account for oxygen corrosion. Tables are given of absorption coefficients of nitrogen, oxygen, and carbon dioxide and of oxygen solubility in water at various temperatures; and American practice in respect of oxygen permitted in feed water is cited. High pressure boiler operation renders determination of residual oxygen difficult; at least one litre is recommended for WINKLER test. **Oil Removal in Boiler Operation.** A. SPLITTGERBER. 146–151. Summary of methods for removal of oil from condensate water are given. Treatment may be with settling tanks, or oil separators, followed by filtration through sodium-calcium-aluminium silicate filter plates, wire cloth, wood wool filters, or similar. Ultra-filtration through collodion, denitrated nitrocellulose, or cellulose acetate, renders water free from oil. Aluminium sulphate and alkali coagulation and filtration methods and also electrolytic treatment are mentioned. **Treatment of Corrosion in Water Tube Boilers.** A. HAENDELER. 151–155. Rust appeared in connection with boiler working at 32 atmospheres pressure with hourly evaporation load of 30 kilograms per square meter heating surface. Condensate from turbines with from 5 to 7.5 percent distillate from lime-soda softened water contained 0.7 p.p.m. dissolved oxygen at 92°. Addition of soda to feed water prevented corrosion. In another case where corrosion occurred, soda number of water was from 600 to 1000 in one boiler drum, but only from 200 to 300 in another; corrosion in latter was stopped by more complete circulation of water. **Rusting and Iron Solution in Unprotected Tubes of Steam Boiler Plants Due to Incorrect Treatment of Feed Water.** K. BRAUNGARD. 156–161. Feed water softened by precipitation methods forms protective coating on tubes, but electrolytic action between dissimilar metals sometimes occurs. Base exchange softening, or distillation, gives water which produces no protective coating and corrosion will occur with oxygen. It is possible to form protec-

tive layer with permutit-treated water by special process; but this is not advocated. Oxygen can be removed by sulphurous acid, or by sodium sulphite, by spraying hot water into vacuum, or by steel wool filter. **Experiments on the Self-Purification of Polluted Water.** J. SMIT. 178–192. All types of bacteria tend to disappear in natural self-purification of water; but since *B. coli*, *B. enteritidis sporogenes*, and streptococci are of importance in water, experiments were undertaken with these to ascertain behaviour when deposited in sterile water. Sedimentation, normal death of bacteria, effect of various bacteria on vitality of others, action of bacteriophage and protozoa, and temperature and composition of water all have their effect upon self-purification.—*W. G. Carey.*

Sulphur Bacteria. DAVID ELLIS. Longmans, Green & Co. 261 pp., 66 illustrations. 215. Reviewed in Water and Water Engineering, **34**: 401, 101–102, March 21, 1932. Complete description and classification of leuco-thiobacteria (colorless) and rhodo-thiobacteria (colored), comprising those organisms which oxidize sulphuretted hydrogen to sulphur, store the latter temporarily, and then oxidize it to sulphate. This monograph is recommended without hesitation to those who desire to extend their knowledge of sulphur bacteria.—*W. G. Carey.*

Water Analysis for Sanitary and Technical Purposes. H. B. STOCKS. Second Edition; revised and enlarged by W. G. CAREY. Charles Griffin & Co., London. 135 pp. 7s. 6d. Reviewed in Water and Water Engineering, **34**: 402, 149–150, April 20, 1932. Physical, chemical (mineral constituents and deleterious metals), and bacteriological examinations dealt with. Miscellaneous determinations include pH value (colorimetric), iodide content, and free chlorine. Preparation of reagents and bacteriological media using ("Difco" products) are given. Reviewer states that he has "no hesitation in recommending it to those who require a really practical book on water analysis."—*W. G. Carey.*